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Transport Canada
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17. Abstract

This report is the first of a two-volume study dealing with the Sea-Bus technology in Vancouver, B.C. Volume One provides a complete documentation of the technologies utilized in the Sea-Bus vessels and terminals. Volume Two addresses the primary and secondary impacts of the system in the areas of transportation, economics, urban development and harbour environment.

Sea-Bus represents an innovative Canadian application of catamaran vessels in urban transit. The Sea-Bus operation uses two vessels, each with a seating capacity of 400 passengers, as a marine transit link across the Burrard Inlet between downtown Vancouver and North Vancouver. Elements and components of the transit service, the catamaran vessel and the passenger terminals are described and illustrated in detail.

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17. Résumé

Ce rapport est le premier concernant une étude en deux tomes sur l'utilisation de la technologie du Sea-Bus à Vancouver, C.B. Le premier tome rassemble une documentation complète sur les caractéristiques techniques du Sea-Bus et des terminus correspondants, tandis que le deuxième étudie l'impact direct et indirect du concept dans les domaines suivants: transport, économie, urbanisme et environnement portuaire.

Le concept du Sea-Bus représente une innovation canadienne dans le domaine de l'utilisation des navires du type 'catamaran' pour le transport collectif urbain. Deux de ces navires, pouvant transporter chacun jusqu'à 400 passagers assis, seront utilisés pour faire le lien entre Vancouver-Centre et North Vancouver par le Détroit de Burrard.

Sont décrits et illustrés en détail les divers éléments et composantes de ce service, les navires eux-mêmes ainsi que les terminus.

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PREAMBLE

In June 1977 Sea-Bus service was established in the port City of Vancouver. It was conceived as a viable alternative to another bridge or tunnel crossing of Burrard Inlet. Since that time this unique marine link in an otherwise all-bus transit system has provided an efficient and reliable service to over 19 million passengers.

After seven years of Sea-Bus service a number of minor problems have surfaced regarding the technology and design utilized in the vessels and terminals. Some of the longer-term impacts of the service have started to manifest themselves. These aspects of the Sea-Bus system as well as its technological attributes have not previously been documented or evaluated.

This study funded by the Transportation Development Centre and Transport Canada's Energy Research and Development Program attempts to provide a comprehensive documentation and evaluation of the Sea-Bus technology and system. The main objectives of the study are:

- to document the technologies utilized in Sea-Bus and to determine the extent to which they have fulfilled the original performance requirements.

- to determine and evaluate the impacts of Sea-Bus on transportation across the Inlet, economics, urban development and harbour operations.

To fulfill these objectives the study has been organized into two major reports. Volume 1, "System Documentation", outlines the main technological characteristics of the Sea-Bus vessels and terminals, including their performance over the years. Volume II, "System Evaluation", addresses the impacts and effects of Sea-Bus as a transportation development.

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1.0 INTRODUCTION

The Sea-Bus is a unique ferry transit system in operation on Burrard Inlet between the Vancouver CBD and North Vancouver (refer to Figure 1). This passenger-only link provides an alternative means to the two bridge crossings of the Inlet and serves as a key link in the bus network. The entire sytem is capable of accommodating long term passenger travel across the Inlet. Upon completion of the Advanced Light Rapid Transit (ALRT) terminal adjacent to the Sea-Bus terminal on the south side, the ferry system will fully integrate with the regional transit system. Sea-Bus is presently operated by B.C. Transit.

The main components of the Sea-Bus system are the two double-ended catamaran ferries, an E-shaped floating terminal on each shoreline, the North Shore bus loop, an elevated walkway on the south side, floating servicing berths and the shore based maintenance and administration buildings. The terminals and on-shore facilities are designed to accommodate up to eight vessels in the future.

The initial design, planning and construction of the entire system cost $35.8 million. Each vessel cost $3.5 million and the two floating terminals totalled $20 million.

Each of the two ferries presently in operation is capable of carrying 400 passengers. The vessels operate at 15 minute intervals during work hours each weekday and on Saturday afternoons. At other times sailings are scheduled every 30 minutes. The ferry service operates between the hours of 6 am and 1 am except on Sundays. The crossing takes about 12 minutes to complete at a vessel speed of 12 knots. The Sea-Bus fare is identical to the bus system (75 cents per adult) and bus transfers are valid for the ferry trips.

Similar to the bus/transit services, Sea-Bus experiences its highest patronage during commuting hours. It also accounts for five percent of the trans-inlet passenger trips. Although Sea-Bus comprises only one segment in the overall transit system, it has certain attributes unlike a typical bus service. Apart from the unique travel by sea the operation maintains a regular service schedule. Since only 400 passengers are permitted on-board (one person per seat) seating is assured at all times. The harbour view and setting also add an asethetic dimension to the trip. This combined with an uninterrupted journey across the Inlet places Sea-Bus in a different category than bus service.

Since its initiation the Sea-Bus service has provided a special addition to the transit system and has effectively connected the Vancouver CBD to North Vancouver.

1.1 Original Design Specifications

In August 1974, the B.C. Department of Municipal Affairs, sought proposals from a number of naval architects to design and supervise

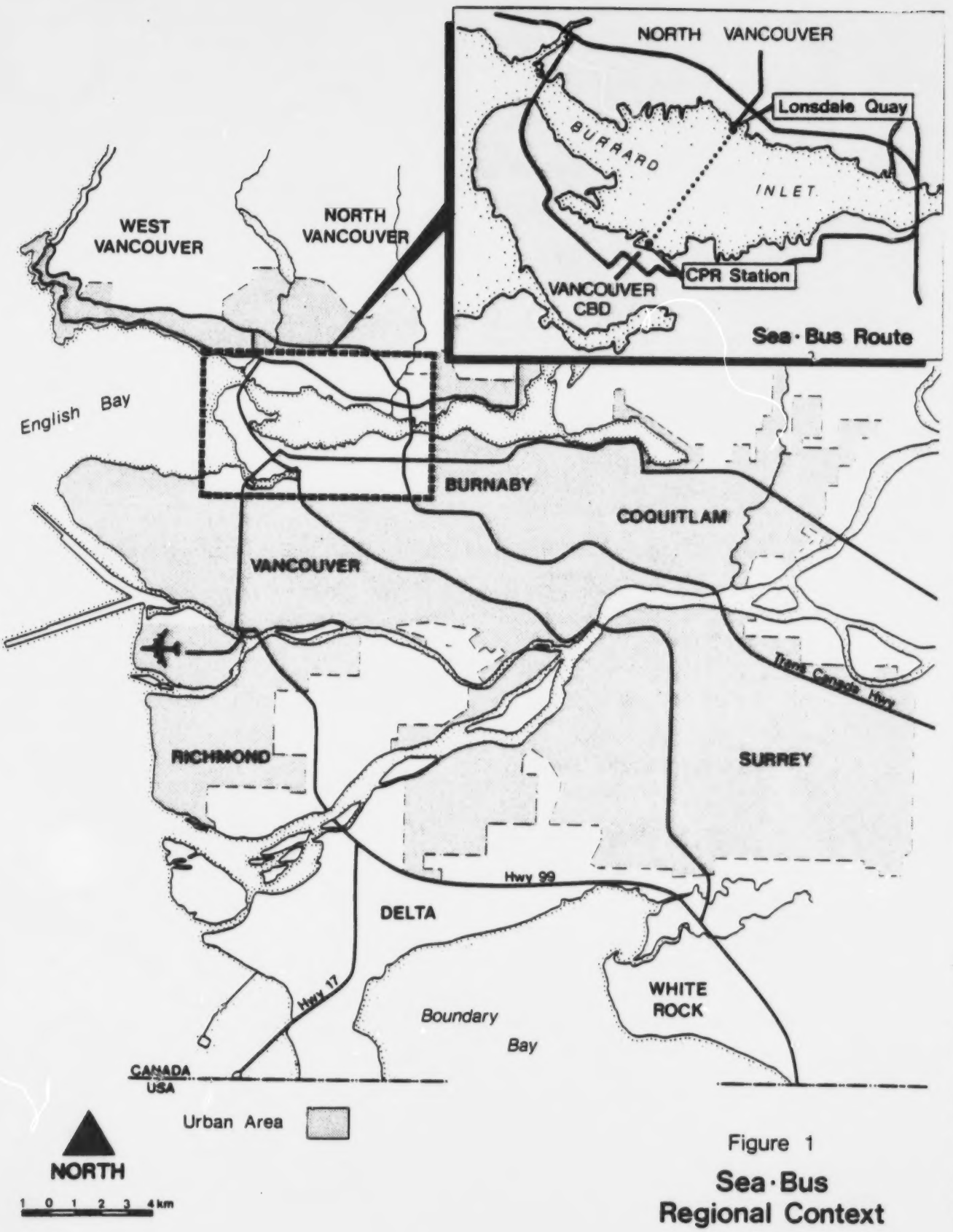


Figure 1

Sea·Bus Regional Context

construction of ferries and terminals for a marine link across Burrard Inlet. The goal was to establish an efficient passenger-only service on the 3.25 kilometre harbour crossing between the North Shore and the City of Vancouver. The ferry service was to connect with shore-side bus services as part of an integrated public transportation system and relieve pressure on the two bridges crossing the harbour. The base capacity of two ferries was selected as being equivalent to one lane of the Lion's Gate Bridge given the rush hour occupancy rate at that time.

The initial requirement for the intended service was a system capable of carrying 400 passengers in each direction every ten minutes with the potential to expand to four times this capacity as traffic increased.

Case Existological Laboratories Ltd. was selected to design and construct the system in accordance with a number of challenging design specifications.

The ships were to be double-ended catamarans with equal speed and monoeuverability in each direction.[1] This would allow for maximum capacity on a given hull length and the great stability of catamarans minimizes heeling while loading and unloading in the terminals. The double-ended design reduces turnaround time and increases safety at the terminals since no turning manoeuvers are required. The passenger deck was to be designed for a 1.5 minute "flow through" loading and unloading. It was calculated that for every one minute delay at the terminals an additional two knots of speed would be required to maintain capacity.

Further specifications called for aluminum ferries to save on fuel consumption and maintenance time and costs. A relatively unique propulsion system was chosen to provide good vessel manoeuverability in the busy harbour.

Each terminal design was to incorporate a passenger floating structure which would automatically compensate for tidal variations of about 5.5 metres.[2] The terminals were to be built to accommodate up to eight ferries in the future. To bring the whole marine link together, maintenance and overhaul berths as well as a maintenance and administration building were to be constructed adjacent to the North Shore Terminal.

1.2 Purpose

The aim of this report is to document the technologies utilized in Sea-Bus and to determine how well they have satisfied the initial performance requirements. For these purposes the vessel and terminal design characteristics are discussed in two separate sections, each commencing with a description of the technology followed by an assessment of their performance since the service started.

The information for documentation of the Sea-Bus technologies such as the catamaran vessels and automatic tide compensating terminals has been obtained from a variety of administration and statistical sources. The performance of Sea-Bus is based on assessments by a number of specialists in the field.

1.3 Waterborne Transit

The utilization of passenger-only ferries comprises an important transportation function in many port cities in the world. Ferry transit is prevalent on both long and short distance routes primarily to connect major city centres with suburban areas.

The Staten Island ferry system, the most extensive in the United States, plays a prominent role in long distance commuter transport. It provides passenger-only and passenger/car service between Staten Island and Manhattan. In Boston passenger ferry service operates on a 16 km route from Boston to a south shore suburb. Moreover, long distance waterborne transit is a integral part of the transportation systems in Japan and Hong Kong.

Short distance travel by ferry across Victoria Harbour is a principal link for commuters between Kowloon and Hong Kong Island. The ferry system in Venice is world renowned not only for serving commuter traffic but as an important tourism facility. In the United States, the Larkspur and Sausalito operation between Marine County and San Francisco comprises an important commuter service. Moreover, 10,000 individuals are carried daily across the Mississippi river in New Orleans. Similarly, use is made of the Chicago River to transport commuters from Union Station (commuter train station) in Chicago to a new office district in the North Michigan area. Other than the Sea-Bus, the Dartmouth/Halifax ferry service forms an integral part of a public transportation system in a Canadian port.

The ferry system operation in Sydney Australia is a major source of transportation for commuter movement across the harbour. In England access to the Isle of Wight is gained only by ferry transit from various port cities on the coastline. The utilization of waterborne transit is confined to a few areas in Scotland.

When compared to the Sea-Bus system and the physical environs of Vancouver only a few of the examples cited are comparable to Sea-Bus in purpose and function. The similar systems include those in use in urban port areas of Sydney, Hong-Kong, Halifax/Dartmouth and San Francisco (Sausalito and Larkspur ferry service).

Each of the ferry systems are in operation in relatively sheltered harbour waters on short crossing routes. They all function as an integral part of the bus transit network and provide regular service, particularly during peak hours to serve the commuter market. Moreover, the ferry systems provide an alternative mode to other trunk routes such as bridges or tunnels across the harbour.

Most of these ferry services operate conventional double-ended vessels except for the Larkspur ferry. The vessel capacity ranges from 400 to 750 passengers depending on the specific vessel design, and travel speed is usually not in excess of 12 knots on the short crossings.

The basic difference between these systems and Sea-Bus is, in part, the vessel technology. The convential type vessels are less sophisticated than Sea-Bus, but they essentially perform the same function. The catamaran hull design has not been utilized elsewhere although the double-ended configuration is common in busy harbours where vessel manoeuvers may be restricted. Thus, Sea-Bus is a rather unique system in its technology and design attributes.

2.0 VESSELS

Catamarans or twin hull vessels are not new but their use in Sea-Bus represents an innovative Canadian application of technology. This feature as well as the unique propulsion system comprises the most outstanding attributes of the Sea-Bus design. The following provides a general description of the vessel design arrangement and an examination of the vessel technology.

2.1 General Description

The Sea-Bus operation uses two vessels called the Burrard Otter and Burrard Beaver to provide the present level of service. They are distinguishable in the harbour by their bright orange exterior and elevated bridge located mid-ship. Figure 2 shows the exterior configuration of the vessels. Both are constructed of aluminum alloy which is lighter in weight than steel. The ferries use diesel fuel with 1.26 million litres required per year to maintain the service. The vital statistics of the ferries are:

Length Overall	34.30 m (112.5')
Breadth Overall	12.65 m (41.5')
Depth to Main Deck	3.52 m (11.56')
Draft Loaded	2.03 m (6.6')
Machinery	4- 12V-71 NA (Detroit Diesels)
Output	4 x 400 BHP
Speed	13.50 Knots
Generators	2 x 120 KW (Detroit Diesels)
Heating & Air Conditioning	Electric
Crew	4

The interior arrangement of the main deck is illustrated in Figure 3. All the passengers are totally enclosed on one level. Seating for 400 is provided in two large sections forward and aft. This large obstructed passenger deck and seating is possible with the catamaran hull design. In the centre portion of the main deck space is allocated for air conditioning and air intake facilities as well as two crew control stations and a crew washroom. There are no public washrooms on-board.

The six double doors on either side of the main deck are arranged to line up with the access doors at the terminals. This system ensures direct "flow through" access and exit at the terminals. With this system loading and unloading can be achieved in less than two minutes.

The spatial arrangement of the bridge is shown in Figure 4. Access is gained from a companion way on the main deck. The bridge design is identical, forward and aft, for each direction and includes the necessary duplicate equipment. All machinery can be started and controlled from the bridge.

Figure 2
Design of Vessels

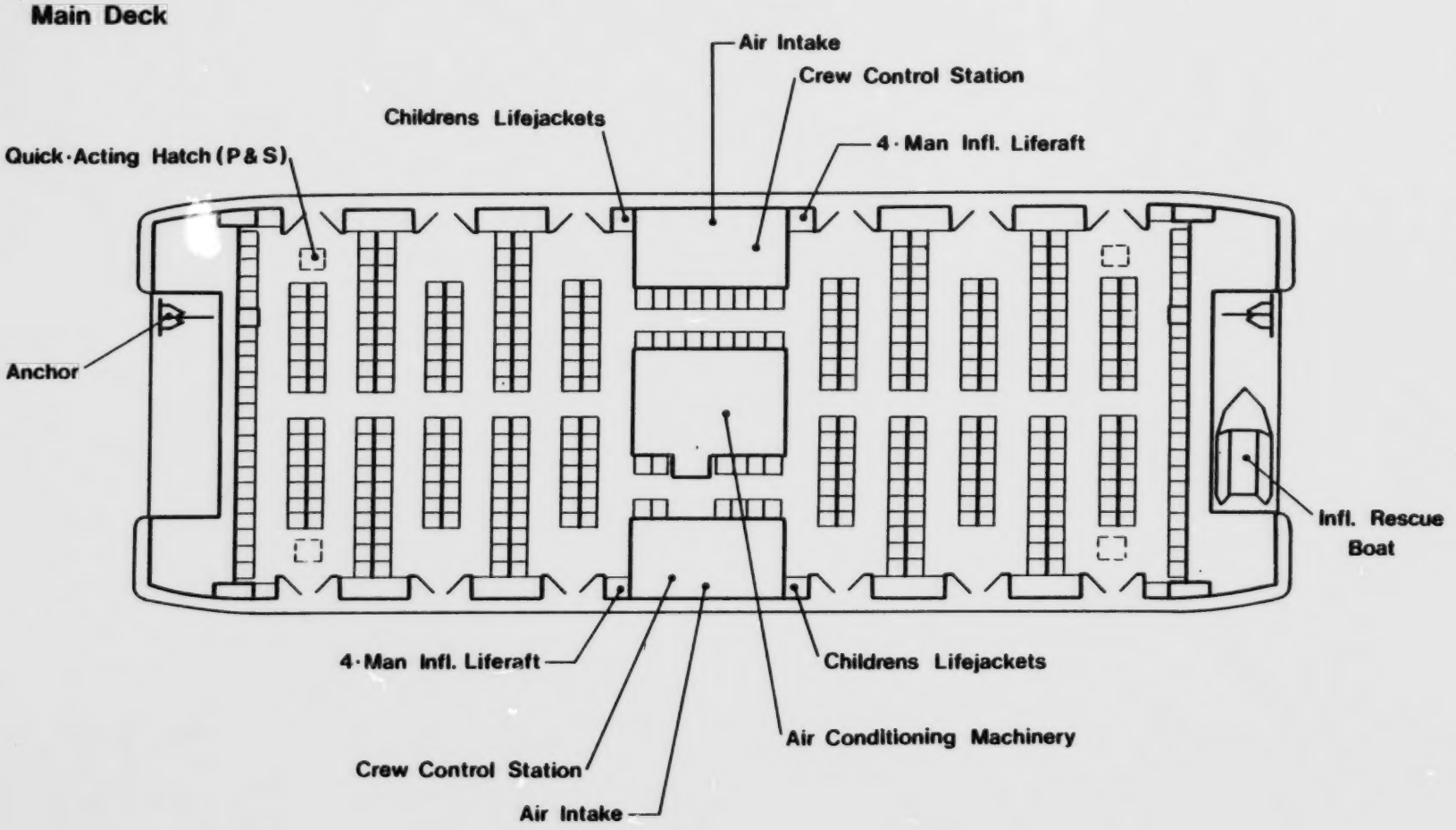


Figure 3

Interior Design and Spatial Arrangement

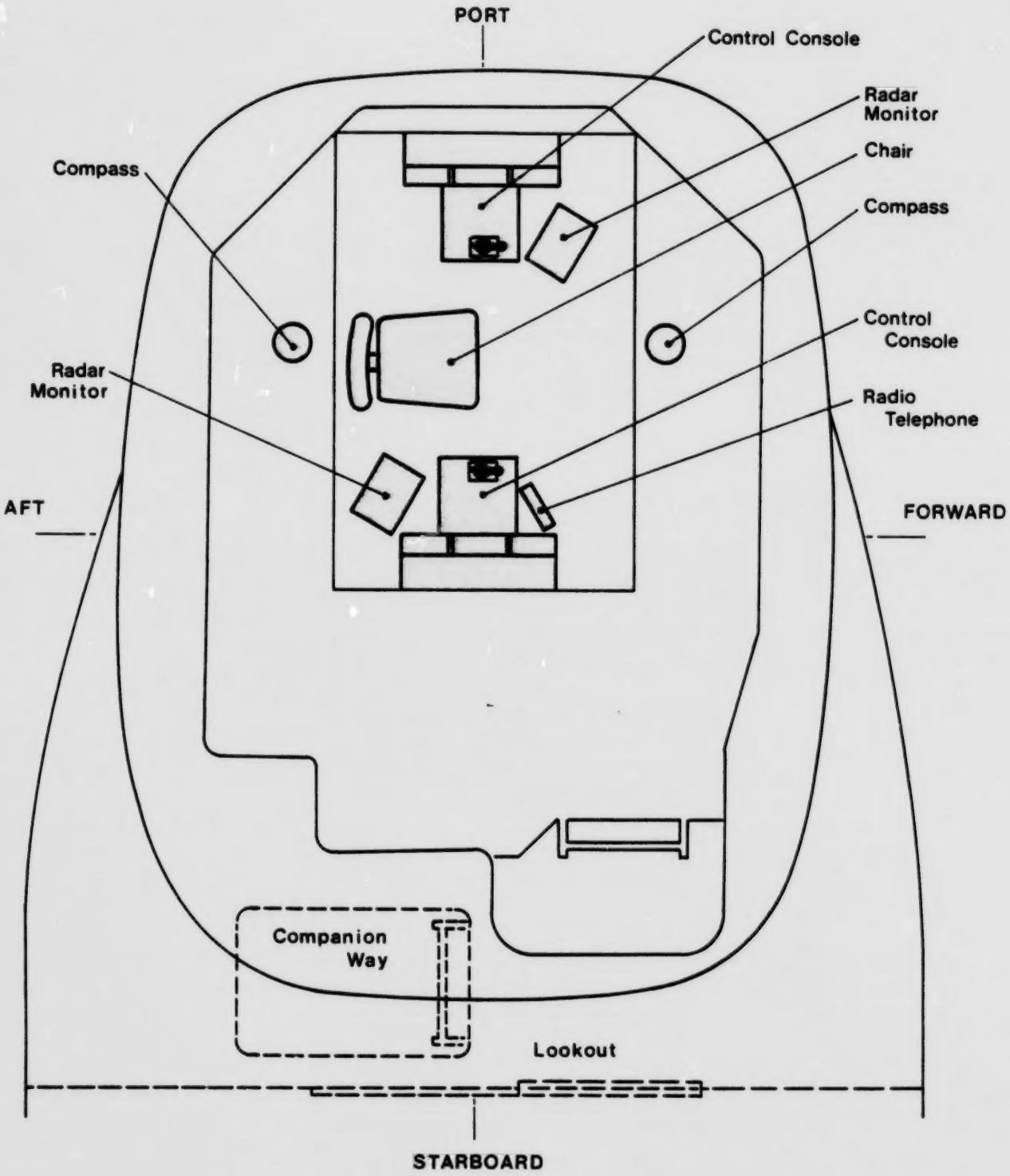


Figure 4

Bridge Design

The lower hull accommodates the propulsion units. Hatches provide access from the main deck for retrieval of various system components for maintenance and servicing.

2.2 Vessel Technology

The main technological features of the Sea-Bus vessels are described below.

2.2.1 Catamaran Hull Design

The Sea-Bus design incorporates a catamaran hull configuration, as shown in Figure 5. The catamaran differs from the more common conventional monohull design in that it is composed of twin hulls. The main attributes of the catamaran design are the large unobstructed passenger deck area which is not possible with a monohull design and the good vertical stability, providing a stable platform while in dock. The hulls are constructed of aluminum alloy and therefore lighter in weight than equivalent steel hulls.

The two demi-hulls are joined by an above-water structure which forms the main deck. The double-ended demi-hulls are symmetrical about the midship plane as well as about their longitudinal centre planes. Figure 6 gives the lines plan of one quadrant of a demi-hull.

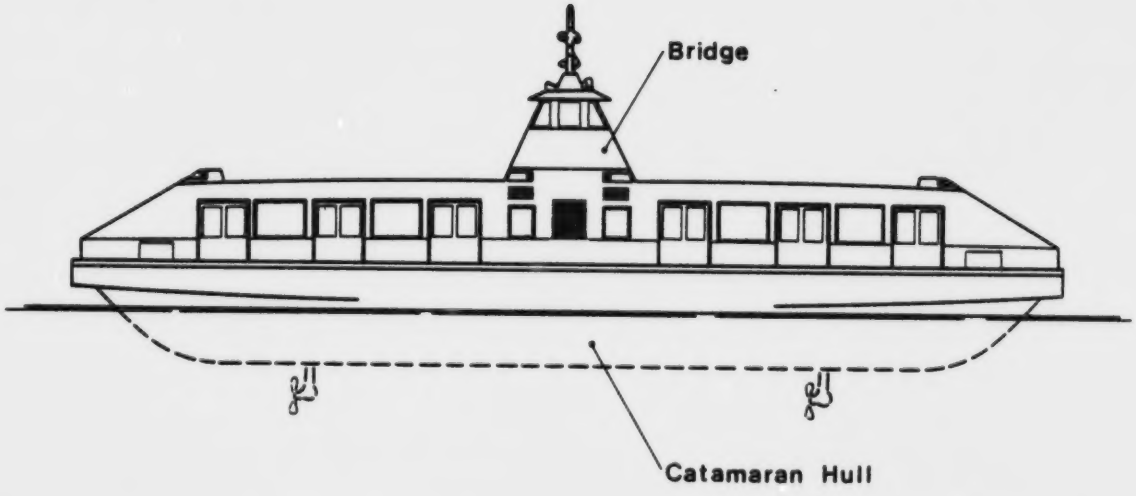
The demi-hulls are hydrodynamically clean due to the unique propulsion system. The propulsion legs which project through the bottoms of the hulls require no projecting shafts, struts or bossings. Apart from the drive units the only protrusions on the hulls are keel coolers for engine cooling water. Also, there is no need for rudders since steering is accomplished by rotating the drive units. Otherwise, the deep narrow demi-hulls with their sharp ends would be slow steering.

The principal particulars of the hulls are indicated in Appendix A.

2.2.2 Propulsion System

The Sea-Bus vessels are operated by a unique propulsion system confined to the lower hull, as shown in Figure 7. This system consists of four diesel engines each driving fully-rotatable right angle drive units with the prop legs protruding through the base of the hulls. The drive units are arranged two to a hull forward and aft. Both speed and direction of the vessels are controlled by two stick levers on the bridge. Each lever controls one pair of engines and propulsion units simultaneously. The port lever controls the forward pair and the starboard lever controls the aft pair. This system makes it possible to turn the ship on its own axis and to move it in any direction ahead, astern or laterally.

Starboard Profile



Forward End Elevation

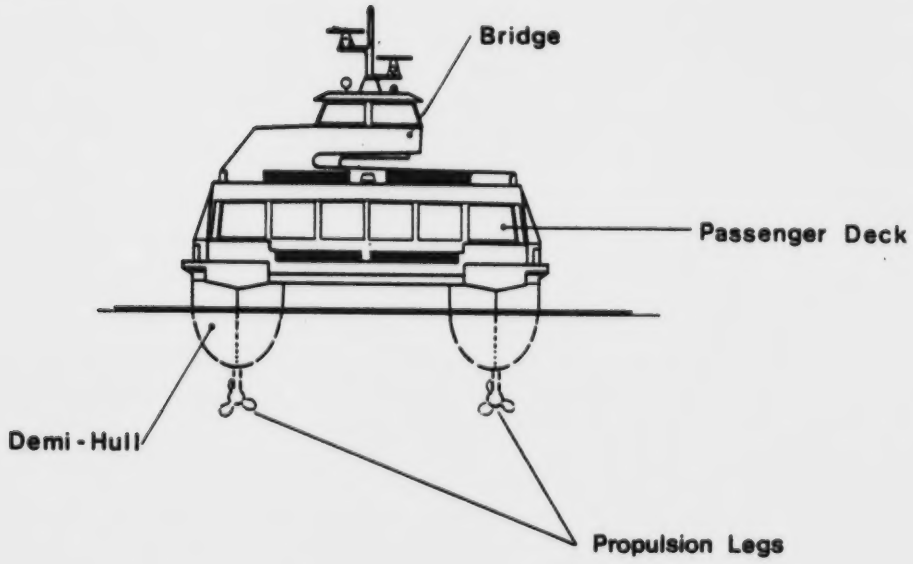


Figure 5

Catamaran Hull Configuration

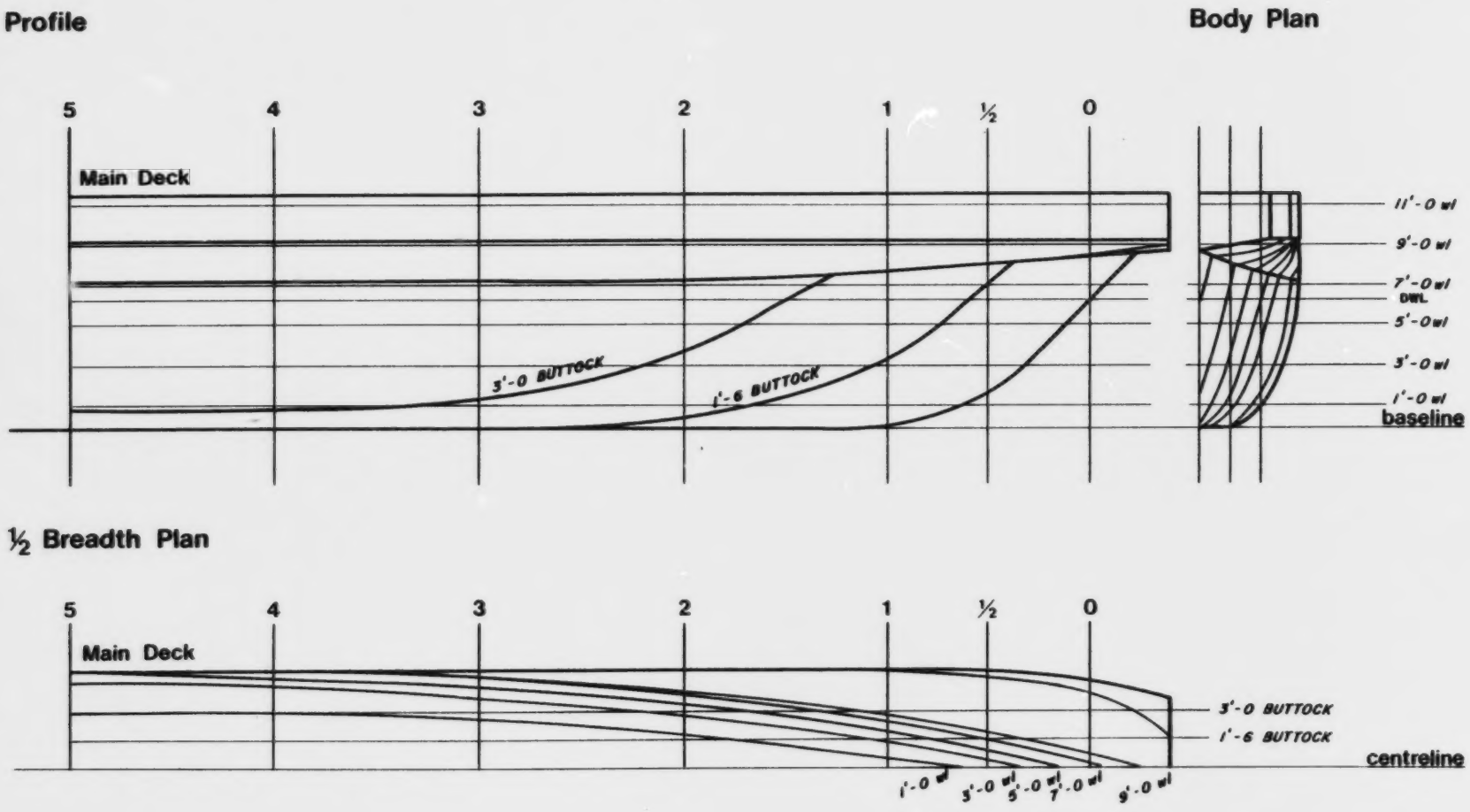


Figure 6

Lines Plan of a Demi-Hull

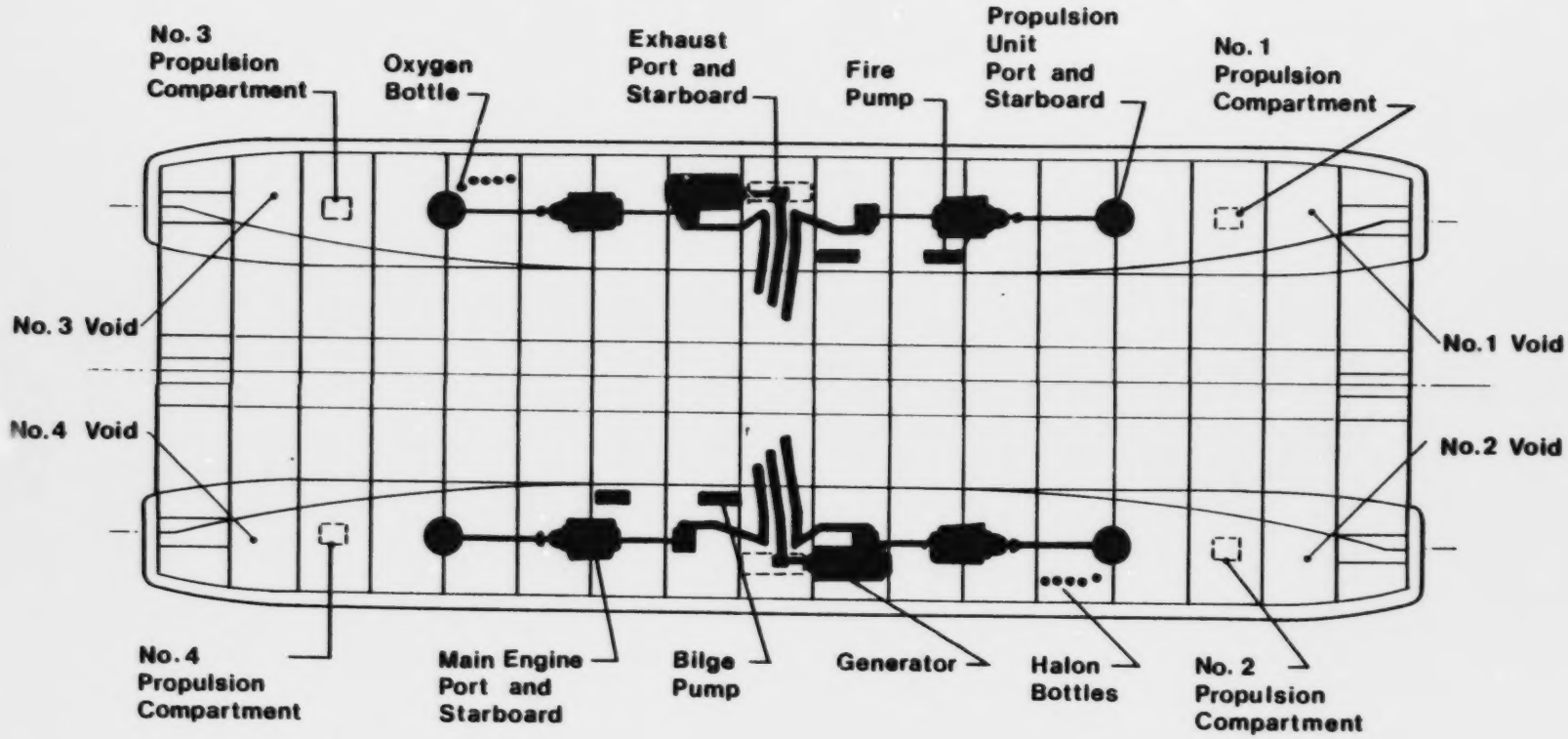


Figure 7
Propulsion System

2.2.3 Navigation and Communications

For navigation and communication purposes the Sea-Bus is fully equipped with radars and a radio telephone. Figure 4 shows the location of these devices on the bridge. Furuno radars with a .40 to 80 kilometer range are fitted in pairs on tracks attached to each control console.

Continuous radio contact is maintained with the Sea-Bus Control Tower and the Vancouver Traffic Centre. The Control Tower is at the front of the North Shore terminal and provides excellent visibility of the harbour and ferry route.

A complete description of the communications system and navigational aids is given in Appendix B.

2.2.4 Safety Measures

The Sea-Bus vessels are equipped with a number of passenger life saving facilities.

In addition to life jackets for each passenger, two inflatable life rafts capable of carrying 31 persons each are stowed on-board. This low capacity was established on the premise that one Sea-Bus would come to the rescue of another. There are also two rescue boats for recovery of personnel from "man overboard" incidents and other emergencies in the harbour.

The vessels are equipped with a complete firefighting and detection system, extensive alarm systems and a number of manual control devices in case various parts of the machinery malfunctions.

The life safing equipment and additional safety features and devices are outlined in Appendix C.

2.3 Technological Performance

The design and technologies utilized in the vessel have proven highly suitable for providing an efficient and reliable transit link across Burrard Inlet. The technological features have in general satisfied the original performance requirements.

The primary drawback of the design seems to be the wash generated by the catamaran hulls. A number of minor problems have been found with navigational aids and, to a lesser extent, with the controls for the propulsion drive units. These problems are discussed in the following subsections along with some of the other limitations and outstanding features of the design.

2.3.1 Passenger Handling

The vessel design lends itself ideally to passenger handling in terms of safety, reliability and comfort. From the point of view of safety the catamaran design offers tremendous stability in the prevailing operating conditions. The hulls can withstand simultaneous flooding of up to one compartment per hull. Since Sea-Bus operates in an enclosed harbour it should survive any minor incident without serious danger to the passengers. The excellent manoeuverability, redundant propulsion units and high visibility (bright orange and strobe lights) of Sea-Bus should minimize the chances of any serious collision occuring.

The reliability of the service is primarily a function of machinery suitability and maintenance. The easy maintenance of the hardware and the aluminum construction has contributed to the excellent service record. There has been no curtailment of service attributable to vessel malfunctions in the six years of operation.

Sea-Bus offers a comfortable ride. The vessel design, however, is suitable only in sheltered waters such as Burrard Inlet. Both the length and breadth of the Sea-Bus are large compared to the wavelengths common in the Inlet. This renders the vessels insensitive to prevailing sea conditions. In more exposed waters a "corkscrew" motion would be created causing a very uncomfortable journey for many passengers and possibly severe sea sickness.[3]

At present the main problem with the vessel which affects the quality of the ride is the noise generated by the engines and drive components. Although the noise level is below the maximum permitted by government standards, a substantial number of passengers indicated the annoyance it causes. According to a recent Sea-Bus passenger survey 36% of the users suggested a reduction in the current noise level inside the vessels.[4]

Apart from this, the reliability of the Sea-Bus service, assurance of a seat, spacious interior design and the aesthetically pleasing journey across the harbour all tend to enhance the quality of the ride.

2.3.2 Design and Space Functions

The double-ended configuration of Sea-Bus has proven successful in minimizing turnaround time and in avoiding ship manoeuvers near the terminal.

The interior space is ideally arranged in relation to the double doors for rapid passenger loading and unloading at the terminals. In addition, the distribution of seating affords most passengers a view of the harbour while the craft is under way. While the interior arrangement of seating and isles are designed for foot passengers only, relatively minor modifications would permit accommodation of bicycles, strollers, wheelchairs, etc.

A deficiency of the interior design of the vessel appears to be the limited space provided on the bridge. Its confined quarters prevent operating personnel from moving about freely. This could affect the general well-being and mental alertness of the crew, and hence the overall safety of the operation.

2.3.3 Propulsion System

The Sea-Bus propulsion system provides excellent manoeuverability and enables precise docking control. The four drive units are capable of going from full ahead to full astern in five seconds for a high degree of safety. Movement in any direction ahead, astern and laterally minimizes the chances of any serious collision occuring with vessels and other obstructions in the harbour.

The only significant problem with this system is associated with the propulsion legs which project through the bottom of the hulls. The damage caused by harbour debris requires frequent replacement of the prop legs. This problem has at no time hampered operations since it is possible to maintain the scheduled service with use of two functional drive units only.

The two stick-levers used for controlling the drive units facilitates vessel manoeuverability, but they can be somewhat difficult to handle even by appropriately trained operators. Operation of the stick lever requires a forward motion to control speed and circular movements for direction. This type of control mechanism is not only unusual compared to that found on more convential vessels but it also requires far more coordination to operate. Some masters never acquire total familarity with these devices.

2.3.4 Wake Problem

There has been considerable protest from North Vancouver marina operators and users regarding the effects of the waves generated by the Sea-Buses. While the actual intensity of the wave train produced is probably no more than that arising from many passing commercial vessels, the frequency and repetitiveness of the crossings caused a high degree of annoyance and concern among owners of boats kept moored near the north terminal. Apart from the discomfort caused by the wash, there have been cases of wave-induced damage to moored small craft.

To help overcome this problem the vessels are now operated at a lower speed of 12 knots for a 12 minute crossing time. As a further precaution the vessels cross the harbour on an angled course rather than direct course in order to create a 0.40 kilometre separation in mid harbour. Turns to the berths are completed off specific facilities located in the harbour to absorb the wash.

The specific design features which cause this problem are discussed under the next heading.

2.3.5 Catamaran Hulls

The performance of Sea-Bus is largely due to the catamaran design. The catamaran provides great stability while loading and unloading and since its rectangular shape allows it to fit snuggly in the berths with minimum clearance. The large unobstructed passenger deck area possible with this design allows for efficient and spacious seating arrangement and quick passenger transfer at the terminals. The capacity available with the catamaran design was a primary consideration for its use. The apparent stability of the craft when underway is more a function of the sheltered route than catamaran attributes.[5] In exposed sea waters the stiff hull design would cause severe righting movements resulting in a "corkscrew" motion of the craft and less manoeuverability.

The wash problems generated by the hulls are mainly due to the high operating speed relative to the length and displacement of the Sea-Bus plus the twin-hull design. With the catamaran design there is a problem of wake interaction so that at certain speeds some extra big swells can be formed in localized areas of the wake.[6] Model tests of the Sea-Bus hydrodynamic performance were conducted at B.C. Research.[7] The experiments showed that both bow wave height and total resistance can be reduced by the use of bulbous bows. Based on the results of another study by Turner and Toplin,[8] Sea-Bus appears quite efficient at a low cruising speed and its performance at a high speed reduces this efficiency. The results of these studies are included in a more detailed discussion regarding the performance of catamaran vessels at certain speeds (refer to Appendix D).

A number of design modifications and alternatives present possible solutions to the wake problem. A longer monohull vessel could operate at the same speed with less wave generation than could a longer catamarar vessel, but many of the outstanding features such as the large unobstructed passenger deck area of the existing Sea-Bus would be lost. It does seem, however, that the Sea-Bus is quite efficient at the present operating speed of 12 knots. Service at this speed has effectively minimized the wake problem.

2.3.6 Safety Devices and Navigational Features

The life saving equipment and all safety measures incorporated into the Sea-Bus design are considered adequate for this type of vessel, and comply with Canadian Coast Guard Safety Standards.[9]

There are, however, a number of navigational devices which require particular attention. The location of radar screens on the bridge is not in the direct line of vision. Relocating them for direct view would be difficult given the confined quarters of the bridge. In addition, it appears that the Furuno radars (0.40 to 80 kilometre range) installed in the Sea-Bus vessels provide marginally adequate bearing and range discrimination. A high definition radar with a

minimum range and bearing discrimination of 20 meters would be more suitable for safe navigation in an enclosed harbour situation.[10]

The curved windows encircling the bridge improve vision but are slanted the wrong way for effective rain and spray throw-off. This, as well as the centre posts on the window frame, hampers visibility.

The location of the bridge wing at a lower level than the bridge imposes difficulties for quick access in case of an emergency. It also restricts communications with the lookout during low visibility conditions.

2.3.7 Design Modifications

Since the Sea-Bus operation started, the vessels have required no major design modifications.

Certain components of the engines in the vessels were altered during the first year of service. The hatches were also modified to provide easier and more efficient access to the engine rooms.

3.0 PASSENGER TERMINALS

The passenger terminals are as important as the vessels in the overall effectiveness of the Sea-Bus system. The terminal design incorporates a number of unique features which provide excellent vessel compatability, integration with the overall transit network and an efficient passenger handling system. This part of the report first outlines the general design characteristics of the terminals including the passenger flow pattern through the system. Following this, the main design and technological attributes are documented and evaluated.

3.1 General Description

A Sea-Bus Terminal is situated on each shoreline, one at Lonsdale Quay on the North Shore and the other at the CPR Station at the foot of Granville Street in Vancouver. The North Shore terminal is integrated with a bus loop and located adjacent to the Sea-Bus Administration and Maintenance area. Figure 8 shows the general layout of this site area. The terminal site and associated facilities on the South Shore are outlined in Figure 9. As illustrated in these Figures, the design of the off-shore floating structures is identical for each site.

The design and interior space arrangement of the floating structures is shown in Figure 10. With the E-shaped configuration the terminals are capable of handling two vessels simultaneously. The interior space is arranged to provide identical passenger loading and unloading facilities for each ferry berth. The embarkation areas, capable of holding 400 passengers each, are situated on either side of the access ramp in the center finger. The disembarkation areas are confined to the outside fingers.

Passengers enter the floating terminal over the gangway ramp. From there they are directed through a set of turnstiles to an embarkation area. The turnstiles automatically shut off at 400 passenger counts. The embarkation area provides seating as well as access to washroom facilities.

Once the Sea-Bus arrives and all departing partrons exit on the opposite side passengers enter the vessel through six automatic doors. This process takes only 90 seconds. Exiting patrons proceed through the disembarkation area and walk along the exit ramp leading to the on-shore facilities.

At the North Shore terminal passengers proceed along the gangway ramp to a walkway which leads to a bus loop. From there they can make connections to any bus route on the North Shore or travel by foot to the Lower Lonsdale area.

Sea-Bus passengers exiting from the South Shore floating terminal follow the gangway ramp to escalators which carries them up to an

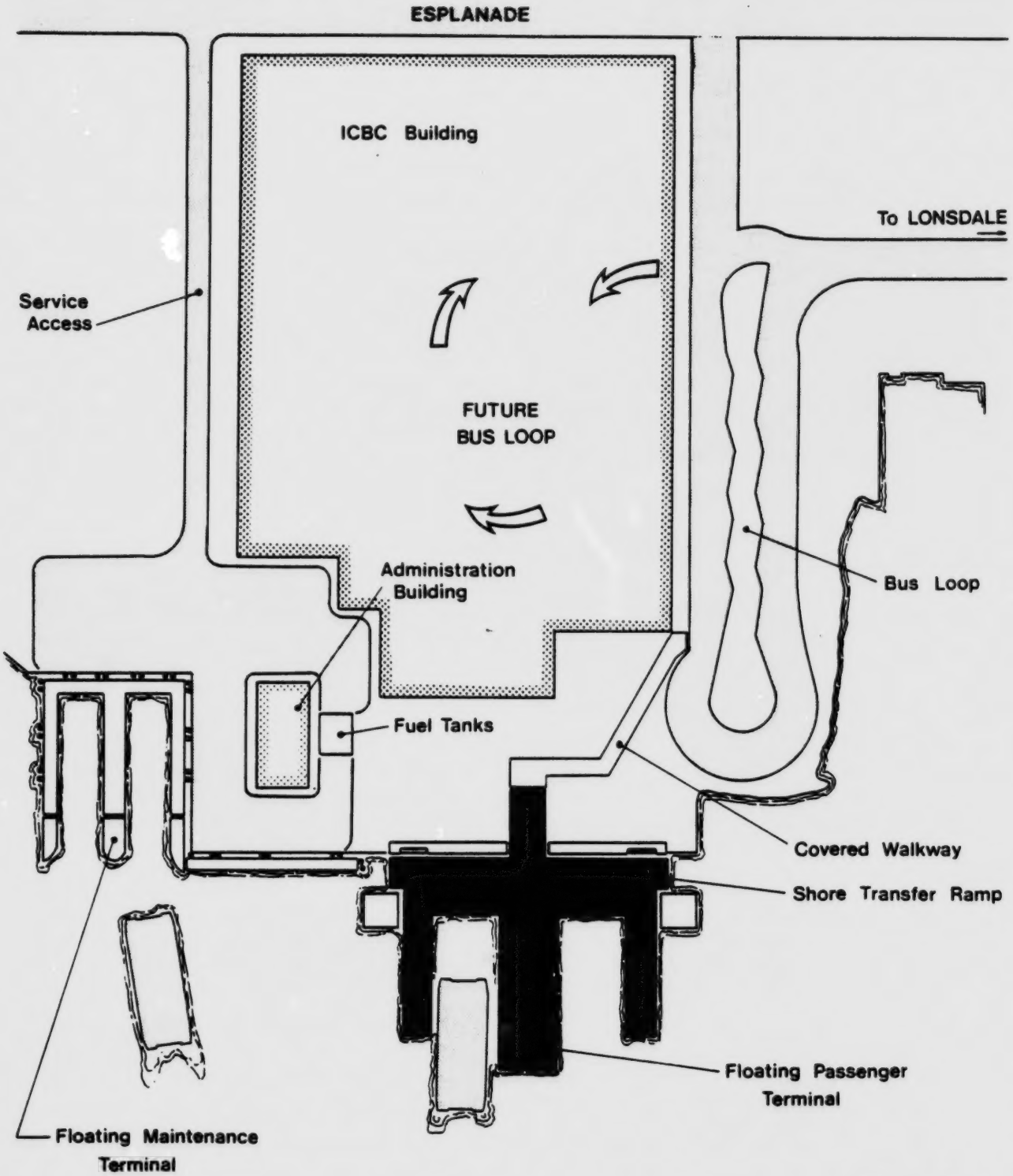


Figure 8

North Shore Terminal Site

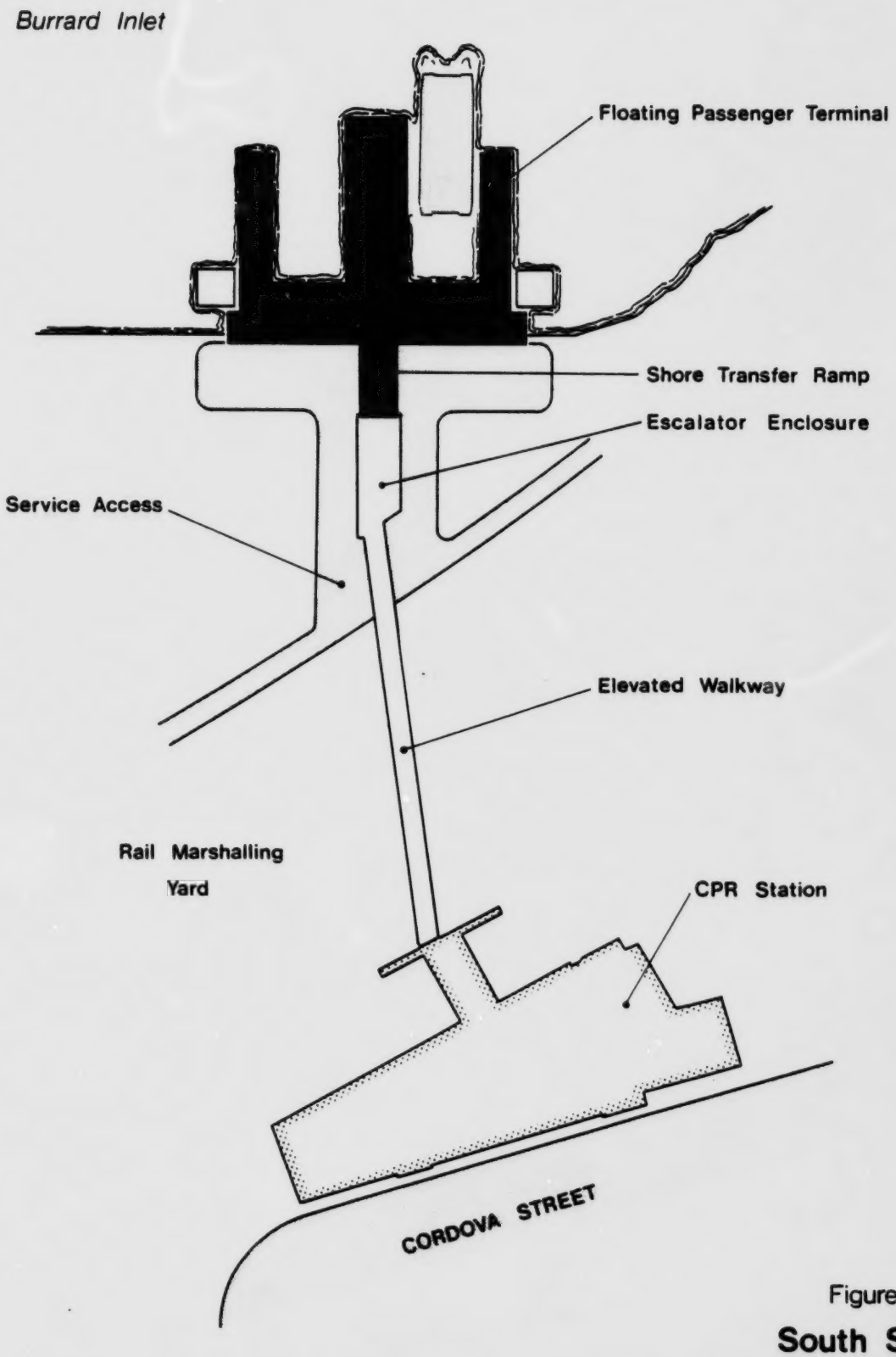


Figure 9

South Shore Terminal Site

enclosed skywalk. The skywalk leads to the CPR Station where street assess is gained through one of the many exit doors. Passengers can board buses on Cordova Street or go on foot from Cordova Street or from the Plaza level at Granville Square to downtown Vancouver. When completed, Vancouver's new ALRT system and Sea-Bus will be integrated at the CPR Station.

Sea-Bus ferry patrons have the option to use bus transfers for their trip or purchase a ticket from the dispenser at the entrance to the South Shore terminal or at the bus loop on the North Side. An information kiosk is provided at the South Shore terminal entrance.

3.2 Terminal Design Features

Description of the technologies utilized in the floating terminals and specific components of the on-shore facilities follow.

3.2.1 Floating Structures

The outstanding design features of the passenger floating terminals are highlighted in Figure 10. These concrete structures float and are completely detached from on-shore facilities. They are held in position by large concrete blocks indicated as dolphins and buttresses in the Figure, and can accommodate tide variations up to 5.5 metres.[11] A fendering system composed of rubber pads is attached to the terminal to cushion it from rubbing against the dolphins and buttresses during normal berthing, wind, wave and current movement.

A fendering system also lines the insides of the berths to serve as a guide for the vessels during docking and to provide a tight fit in the terminal. Along with this system the shock-absorbing buffers at the head of each berth ensures that the access doors on the ferry and terminal line up to provide straight through access and exit.

A steel pile wall which acts as a land fill retainer also separates the floating components from the fixed facilities. These structures are connected by a gangway ramp which is hinged to allow for tidal movement.

The floating terminal vital statistics are:

Length Overall	79 m (260.0')
Width Overall	80 m (262.0')
Ferry Berth Length	36 m (117.0')
Height above Main Deck	6 m (20.0')
Depth of Hull	5 m (17.0')
Weight Unloaded	9,130 t
Total Deck Area	2830 m^2 (30,500 sq. ft.)
Wall Thickness	71 cm (0.10')
Concrete Compartments	86
Total enclosed Floor Area	1900 m^2 (20,500 sq. ft.)

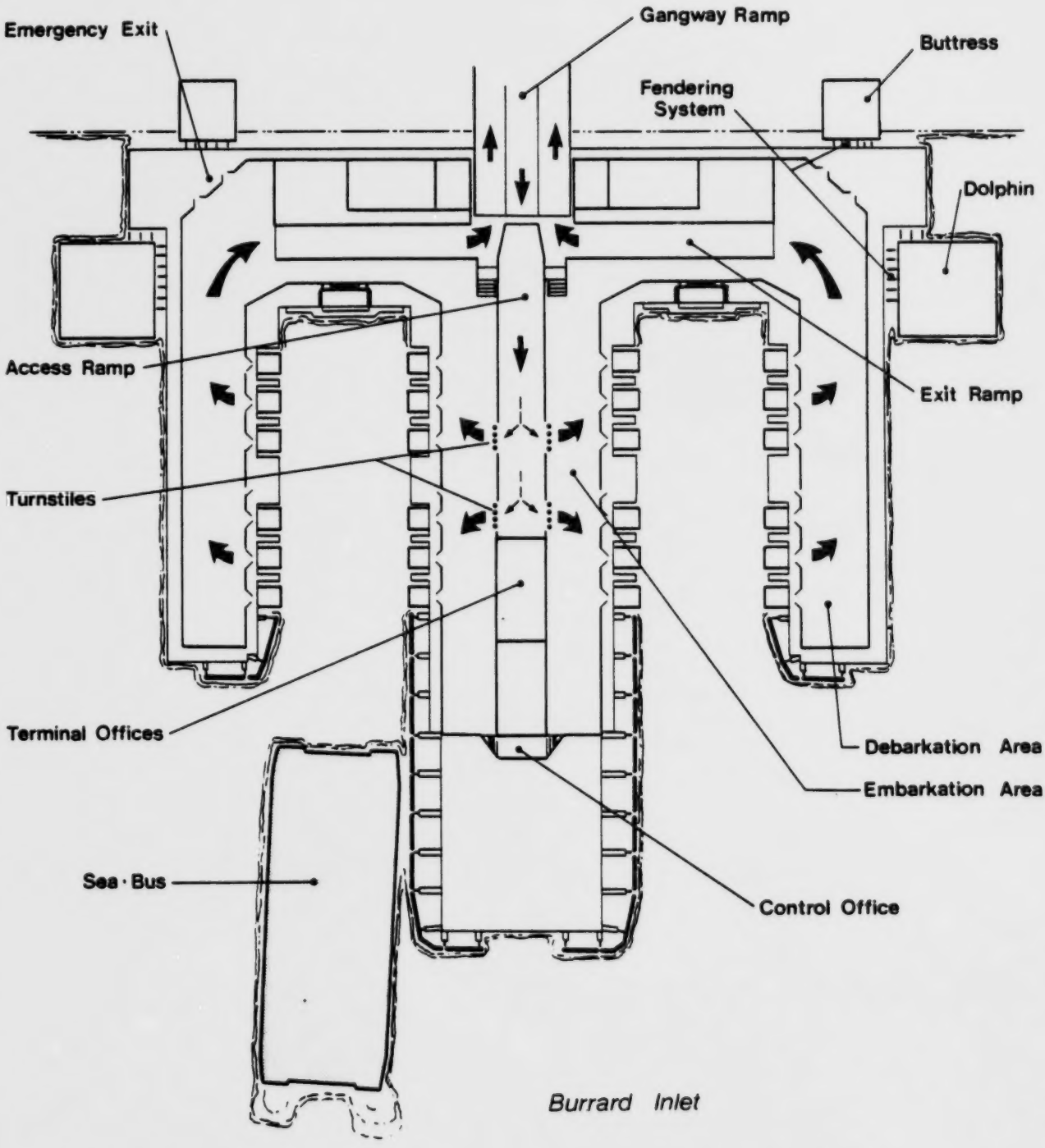


Figure 10

Passenger Floating Terminal

Design Features and Passenger Flow Patterns

Shore Terminal Access Ramp		
Length	26.4 m	(86.7')
Width	9.9 m	(32.3')
Depth	2.9 m	(9.4')

3.2.2 On-Shore Facilities

The land-based terminal facilities are detached from the floating structures and are connected by a hinged gangway ramp. Figure 8 illustrates the integration of the North Shore floating structure with the covered walkway which leads to a sheltered bus loop. A new bus facility near completion on the same site, but underneath the ICBC Building, will replace the existing bus loop. The new bus terminal will be competely enclosed including the walkway extending from the Sea-Bus floating terminal structure.

On the South Side the on-shore facilities comprise four reversable escalators which lead to an elevated walkway over the rail yard (refer to Figure 11). The walkway is constructed of structural steel framing and enclosed by a steel plate floor, glass walls and a flat roof.

3.2.3 Security System

The Sea-Bus terminals are equipped with a closed circuit television security system which covers all public areas in the terminals. It is constantly monitored by Ferry Operating Personnel.

3.2.4 Fare Collection System

A self-serve fare machine is provided at each terminal facility. The dispenser issues a transfer with the date, time and amount of fare paid, and thus serves as both a transfer and fare receipt. The fares are shown by an imprinted image of the coins. The image of the coins, time and date is often difficult to read unless viewed at a close range.

The exact fare must be paid at the self-service machine before entering the turnstiles at the embarkation areas. With this system delays are avoided while passengers are loading onto the vessels.

3.3 Terminal Design Evaluation

The various design elements of the passenger terminals were thoroughly investigated to assess their durability and overall performance since the Sea-Bus operation started. It was generally found that very few problems have been encountered other than those due to normal wear and tear. The overall design appears to be ideally suited for rapid and efficient passenger processing. It is compatible with the vessels and well integrated with the public bus system. The main design shortcoming appears to be the absence of wheelchair access in the South Shore terminal. This, as well as other design limitations are outlined in the following sub-sections.

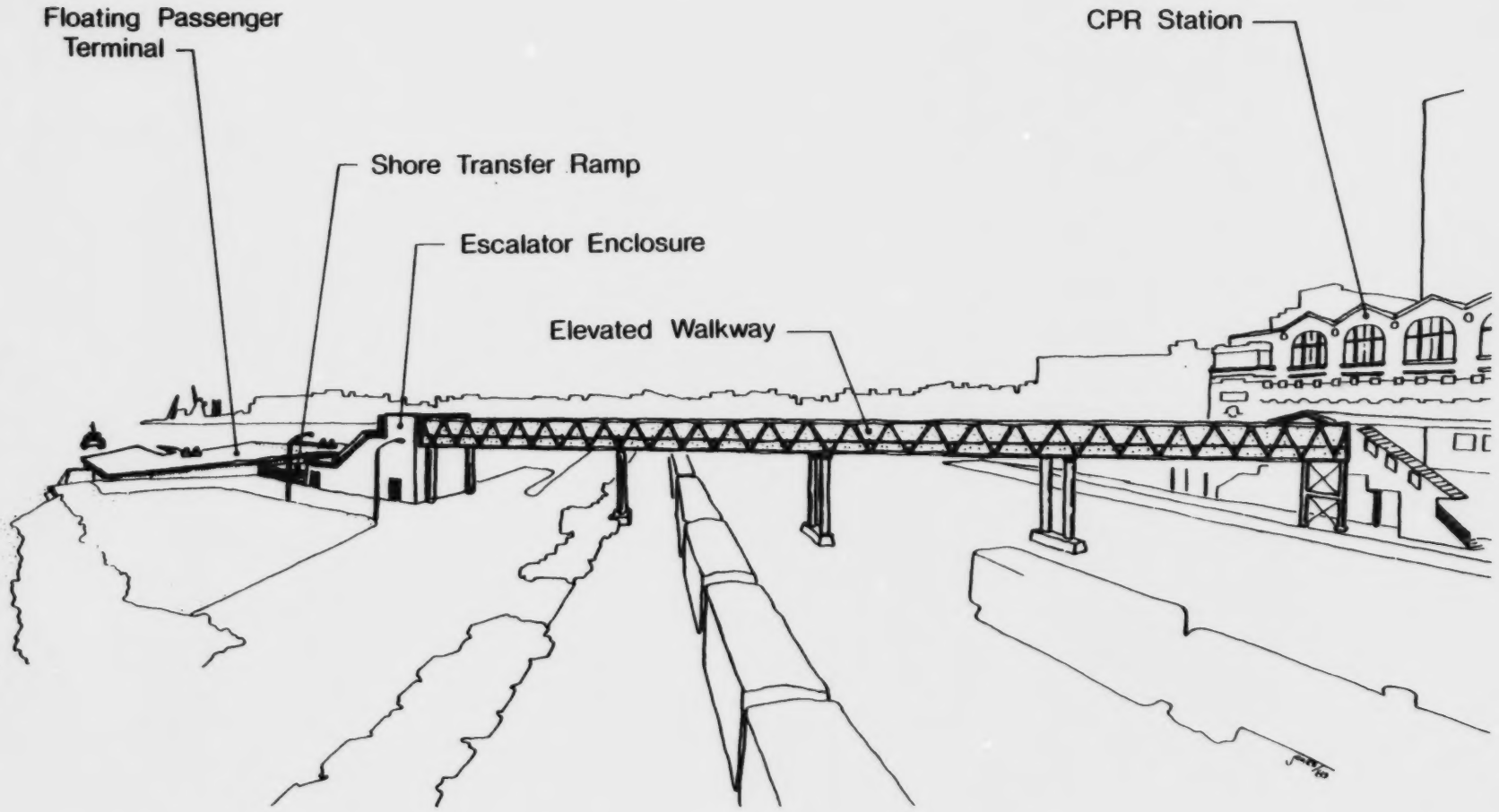


Figure 11

South Shore Terminal
Land Based Facilities

3.3.1 Bicycle, Baby Carriage and Wheelchair Access

The regulations of the Sea-Bus system dictate the bicycles are limited to use of the ferries on Saturdays, Sundays and holidays. Motorcycles, tricycles or mopeds are not permitted on-board at any time.

There are two areas within the system that present obstructions to bicycles, baby carriages and wheelchairs. One is the turnstiles at the embarkation areas. Use of the emergency exit doors overcomes this problem.

The second obstruction is the escalators in the south terminal. Bicycles must be carried on the escalator. This may be manageable for an adult but presents difficulties for small children. A bicycle not kept in control could easily fall down the escalator and endanger other passengers.

The problem of access for baby carriages are very similar to those of bicycles. The only basic difference is that there are no restrictions as to the time of the day or week when baby carriages may be taken on the ferries.

Access for people confined to wheelchairs is more problematic, particularly in the south terminal where there are no facilities other than the escalator between the lower escalator enclosure and the walkway to the CPR station.

The design of the passenger ramps at both terminals complies with the gradient requirements of the National Building Code. However, it does not meet the requirements for intermediate landings on the ramps which function as rest areas for wheelchair patrons. It is impossible to provide level landings on the transfer and exit ramps due to tidal movements but they could have been accommodated in the design of the access ramp. Figure 10 shows the location of these ramps.

Entry to the embarkation area through the turnstiles is impossible for wheelchair passengers and quite difficult for an individual on crutches, etc. There are emergency exit doors through which a wheelchair can pass but this requires the assistance of ferry personnel.

Provision of access for handicapped was not a requirement at the time when the Sea-Bus system was designed.

3.3.2 Spatial Arrangement

The floating passenger terminals contain limited space and seating in the disembarkation area. This area tends to become very congested when it is fully occupied. In comparison to the existing

standards used by Transport Canada for sizing Air Terminal holding areas and the standards used in the Greater Vancouver Light Rapid Transit System (presently under construction) for sizing the loading platforms at the Transit stations, the Sea-Bus terminal provides 2 m^2 per person while 2.5 m^2 is alloted for the Light Rapid Transit stations and 3.3 m^2 in Airport Terminals.[12]

3.3.3 Structural Elements

Most of the structural elements including the floating components of the terminal appear to be in good condition. Some corrosion exists where the concrete bases join the terminal walls which are constructed of structural steelwork.

All exterior finishes are coated with protective agents to prevent direct contact with salt water. The interior wall finishes are primarily vinyl face panels which are highly durable and easy to maintain.

3.3.4 Safety Codes and Regulations

With some minor exceptions the terminal structures comply with the building and safety requirements of the 1970 National Building Code. The emergency ramps which provide access directly out of the disembarkation areas have twice the gradients permitted by the Code (1:5 vs 1:10).[13]

4.0 MAINTENANCE

The vessel maintenance area is situated west of the North Shore passenger terminal, and is illustrated in Figure 12. For vessel servicing two floating maintenance berths and one overhaul berth were designed to accommodate three vessels at any one time. Facilities are available for re-fueling and washing and cleaning the vessels on a regular basis and for carrying out other routine maintenance tasks.

The concrete floating berths are held in position by steel piles. A fendering system attached to the floats act as guides for the vessels. Elevated timber walkways are connected to the floats for use by the maintenance staff.

There have been some changes to the original layout of the facilities. The main overhaul berth proved to be too exposed for its intended purpose and has been moved from its original location alongside the shore. It is presently used as a working barge and as an additional dock. All maintenance and overhaul work is now carried out at the two ferry berths. Figure 13 shows one of the berths. Other than this, the remaining facilities appear to be in good condition. The timbered walkways are showing signs of age and weathering.

4.1 Servicing Procedures

Most vessel servicing and major repair work takes place in the evening when the Sea-Bus operation requires only one vessel for service. During the day with both vessels operating, minor repairs are carried out while the vessels are in motion. A marine engineer is on duty in the North Shore maintenance yard 24 hours a day.

As part of the daily maintenance procedures the vessels are refueled with diesel fuel pumped from 45,500 litre storage tanks. Lube oil is replenished weekly. In both of these instances precautions are taken to minimize any chances of a fuel spillage.

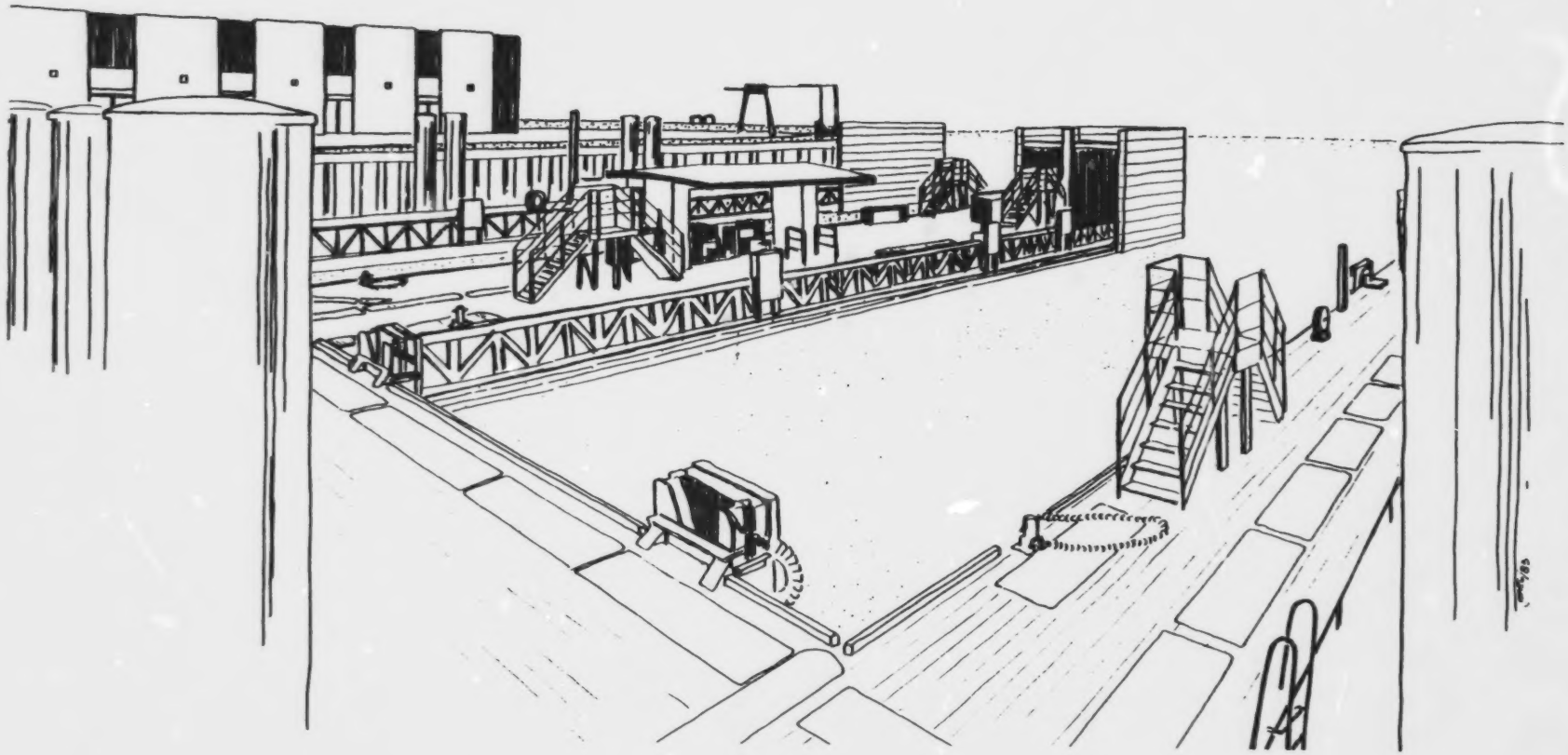


Figure 12
Maintenance Terminal

5.0 SUMMARY AND CONCLUSIONS

The Sea-Bus system appears to be a well thought out solution to a complicated transportation problem. The passenger-only ferry link connecting the North Shore to the City of Vancouver has carried over 19 million passengers since the operation began in 1977. The service supplements the two bridge crossings of Burrard Inlet and plays a prominent role in the overall transit system.

The concept of ferry transit is not unique to the port city of Vancouver nor are the Sea-Bus technologies as individual components, new ideas. The use of the technologies in Sea-Bus, however, represents an innovative Canadian application of technology. The assembly of the main design features of the vessels including the double-ended configuration, the propulsion drive units, and the catamaran hull together with the floating passenger terminals, has provided a unique transportation link capable of handling passengers efficiently and comfortably across Burrard Inlet.

The double-ended vessel configuration appears to be a common design feature in port situations where manoeuverability is restricted and rapid passenger loading and unloading is desired. This design attribute, along with the four fully rotable propulsion drive units employed in the Sea-Buses, provide excellent vessel manoeuverability and safety in the busy port of Vancouver.

The catamaran hull design made it possible to provide a large seating capacity on the main deck. The high vertical stability of the catamaran is particularly suitable for precise and efficient vessel docking and control thereby increasing passenger safety while loading and unloading at the terminals.

The main problem with the vessel design has been the wake produced by the catamaran hull. A number of properties bordering on the shorelines near the terminals have sustained damage from the wave action. Although the wash problem has been minimized through to the introduction of course changes and by a reduction of vessel speed, design modifications to the hull may be required for future ferries.

The floating passenger terminal and vessel design characteristics have been fully integrated to ensure a rapid and safe passenger "flow through" system with side door loading and unloading.

The terminals on each shoreline have identical floating components and different land based facilities. The floating facilities can withstand tidal variations of 5.5 metres. This reduces the chances of service interruption during adverse sea conditions and tidal fluctuations. The E-shaped floating configuration is capable of handling two vessels simultaneously. The design arrangement provides separate facilities for passenger embarkation and debarka

tion. The floating structures are connected to land based facilities by a hinged ramp. These on-shore facilities provide major dispersal points for bus transfer or travel on foot.

The only problem evident with the terminal design is associated with the land based facilities on the south shore. Although not required at the time of construction, there is no provision for handicapped access at the escalator enclosure area.

After seven years of Sea-Bus operations the technologies have met the original performance requirements of system capacity, vessel manoeuverability and safety, service reliability, and terminal/vessel compatability with a rapid and safe passenger handling process. The problems associated with the technology are, for the most part, minor. Experiments conducted with the catamaran hull suggest that slight modifications may be desired for future ferries. Overall, the assembly of the technologies in Sea-Bus has been successful in providing an unique and efficient form of transit service.

In summary, the main characteristics of the Sea-Bus system are:

Service

. Sailing frequency of 15 minutes during weekday work hours and part of Saturdays and 30 minutes the remainder of time.

. Option to use bus transfer or pay separately at self-serve pay machine for each trip.

. Fare payment equivalent to buses.

. Interconnected with bus system at both terminals.

. Trip crossing of 3.25 km in 12 minutes at a speed of 12 knots.

Vessel Technology

. Double-ended exterior design with elevated bridge located mid-ship.

. Four fully-rotatable propulsion drive units, two forward and aft.

. Catamaran or twin hull configuration.

. Spacious interior with seating capacity for 400 passengers.

. Side door entry and exit for passenger loading and unloading.

Passenger Terminal Design

. Floating off-shore structures connected to land-based facilities by a hinged ramp.

- North Shore floating terminal integrated with a bus loop.
- South Shore floating facilities connected to CPR Station by an elevated skywalk.
- Land-based facilities as major dispersal points for bus transfer or travel by foot.
- Floating components automatically accommodate tidal variations up to 5.5 metres.
- Separate passenger flow pattern for embarkation and debarkation.

Appendix A

1.0 Principal Particulars of the Catamaran Hull

The following dimensions and co-efficients describing the Sea-Bus hull(s) are taken from the report by Gerald Stensgaard referred to as B.C. Research Project No. 4-02-224 in the Reference Section.

Length Overall	34.30 m (112.5')
Length of Design Waterline	31.85 m (104.5')
Beam Overall	12.65 m (41.5')
Demi Hull Type	Symmetrical about centreline
Beam of Demi-Hull (Moulded)	3.05 m (10.0')
Depth (Moulded)	3.52 m (11.56')
Clearance from D.W.L. to underside of Wing	0.91 m (3.0')
Displacement to Design Waterline	203.7 t (200.5 L.T.)
Block Co-efficient	0.554
Prismatic Co-efficient	0.662
Volumetric Co-efficient (demi-hull)	3.07
Design Service Speed	13.5 kn

Appendix B

1.0 Communications System and Navigational Aids

The following outline of the type and location of the communications system and navigational aids specific to each vessel is based on information obtained from the "Master Sea-Bus Information Manual".

1.1 Communications System

- a Communications Console located in the wheelhouse which includes a Master Control Station, a Remote Control Station, a Communications Control Chassis and an Outboard Control Console.
- a Public Address (P.A.) System with eight flush mounted speakers located throughout the passenger area.
- a 55 channel Radiotelephone, V.H.F., F.M., tuned to the shore based terminal which is stations. Refered to as the "Terminal Radio".
- a Loud Hail Listen/Talk System with a four way omni-directional speaker.
- Intercom system in the Crew Control Stations on the Passenger Deck.

1.2 Navigational Aids

- two radars, forward an aft in the wheelhouse.
- two search lights and one set of navigational lights.
- two nagivational clocks.
- two magnetic compasses.
- one pair of binoculars.
- one floating blue strobe light on the top of the mast.

Appendix C

1.0 Life Saving Equipment and Operational Safety Features

The following list of on-board safety features is taken from the "Master Sea-Bus Information Manual".

1.1 Life Saving Equipment

Life Jackets (Adults)	406 (Stored Under Seats)
Life Jackets (Children)	41
Life Buoys with Heavy Lines	4
Life Buoys Launching Areas	Bridge Wing, Port and Starboard Crew Doors
Man Over Board Access Ladders	One (1) Port, One (1) Starboard at crew control stations.
Rescue Boat	12 ft. inflated four-man dinghy

1.2 Fire Fighting Equipment

Wheelhouse	One (1) five pound CO_2 extinguisher
Accommodation	Two (2) two gallon fluid extinguisher Two (2) fire main stations
Auxiliary Machine Rooms	Two (2) five pound CO_2 extinguishers one in each compartment.
Engine Rooms	Two (2) fire main stations one in each engine room. Total Halon 1301 flooding in each engine room, two independent systems controlled from the port and starboard crew control stations (outside the (engine room accesses) and from the wheelhouse. Two (2) five pound CO_2 extinguishers, one in each Engine Room.
Fire Pumps	Two (2) on a pressurized system, one in each engine room, low pressure audio/visual alarm in the wheelhouse, remote start in the wheelhouse, local control at the pumps.

1.3 Fire Detection

Fire Watch Passenger Deck	Continous surveillance by two crew members in passenger area.
Automotic Fire Detectors	Passenger Lounge Auxiliary Machinery Rooms Engine Rooms Propulsion Compartments

	Manual Alarm	Passenger Lounge (2) Engine Rooms (2) Propulsion Compartments (4)
	Operation	Audio/Visual alarm in wheelhouse alarm panel, automatic and manual ventilation shut down, emergency 24 volt D.C. supply.
1.4	Propulsion System	
	Manual Back Up Control	Emergency direction and speed control local to each engine and drive unit, emergency communcation system with stations at the forward and aft areas on the passenger deck and in each engine room and propulsion compartment.
	Alarm Panels	Four (4) alarm panels, one for each engine and drive unit combination, one light and audio alarm in the wheelhouse for each alarm panel indicating any one alarm being activated in the engine rooms.
1.5	Bilge Systems	
	Automatic Emergency Bilge Pumps	Eight (8), two in each engine room, one in each propulsion compartment, submersible type.
	Operation	Automatic starting and stopping, audio/visual alarm in wheelhouse, push buttom start from the wheelhouse.
	Bilge Level Alarm	Eight (8) sensors, two in each engine room, one in each propulsion compartment, audio/visual alarm in wheelhouse, independent of automatic bilge system.
	Normal Bilge System	Two (2), one in each engine room, two manifold stations, one in each engine room, bilge piping to all engine room and propulsion compartment, discharged ashore.
1.6	Electrical System	
	Generators	Two (2), one in each engine room, remote start/stop from the wheelhouse, one operating and one standby.

	Operation	Standby generator start automatically on failure of the running one, with automatic safety shut downs.
	Alarm Panels	Two (2), one for each generator, one light and audio alarm in the wheelhouse, indicating one or more alarms being activated at the generator.
	Emergency Batteries	Emergency battery bank in wheelhouse structure, automatic operation, provides one (1) hour of emergency power.
	Emergency Loads	Emergency lighting, all navigation and communications systems.
	Switchboards	Two (2), one in each hull providing generator, metering, protection and control. Distribution and automatic transfer switch located on passenger deck.
1.7	Passenger Doors	
	Operation	Twelve (12) power operated (6 per side). Electrical opening/closing from crew control station, emergency manual operation at each door, over/center lock, passenger protection system (door re-opens if passenger is jammed in during load/unloading operations).
	Alarms	Audio/visual alarm in wheelhouse and crew stations if any door becomes unlocked during transit.
1.8	Anchors	
	Number	Two (2) one forward, one aft, Danforth, 180 pound anchors, each with 6'-0" of 1/2" diameter, chain and 450'-0" by 3/4" diameter, braided nylon ropers stowed on reel.
	Operation	Released by levers one forward and one aft located on the passenger deck.

Appendix D

1.0 Performance of Catamarans at Various Speeds

The performance of the Sea-Bus discussed below is extracted from the study of catamaran hulls by Gerry Stansgarard, B.C. Research Project No. 4-02-234 (refer to Reference Section).

Regarding speed under way, we first note that the Sea-Bus demi-hulls are of the symmetrical type which, generally seem to be less resistive than those of assymetrical form. The hull design is based on a service speed of 13.5 kn which places the Sea-Bus in the classification of moderately fast displacement vessels.

At this speed the Froude number is 0.379 (speed - length ratio = 1.27) which is quite close to the so-called "hull speed", Froude number of 0.400 (speed-length ratio = 1.34). This means that the vessels operate well within the speed range where wave-making resistance is an important component of the total resistance. In this speed range, a prismatic co-efficient falling between 0.58 and 0.62 would be appropriate, while the published value for each demi-hull is 0.662. This suggests that the hulls are slightly too full for maximum ease of propulsion, but since stern squat is known to be a serious problem in this design, the extra buoyancy in the ends may not be amiss. The volumetric co-efficient of 3.07 per demi-hull is slightly higher than the normal practice for monohull displacement ships, and is therefore, in direct contradiction to one of the previously stated advantages of catamarans, namely the possibility of splitting displacement into two demi-hulls and thereby reducing the residuary (wave-making) resistance of the catamaran compared to the equal - displacement monohull. There has been a problem with the wakes of the Sea-Buses disturbing shoreside installations and this is not totally surprising given the 13.5 kn speed at which these relatively full, heavy hulls were originally driven. This wake problem has been mainly responsible for the Sea-Bus service speed being reduced to 12.0 kn at present. In retrospect, longer lighter hulls would have permitted more easily driven hulls with minimal wake, but would possibly have cost more to build. Since the present deck area is satisfactory for the specified capacity, a longer vessel could have somewhat closer hull spacing if of catamaran form, or alternatively, a superstructure shorter than the demi-hulls.

To complete the documentation of the Sea-Bus' hydrodynamic performance, we now present some results of recent model tests conducted at the Ocean Engineering Centre of B.C. Research. Figure 1 is a plot of total resistance versus speed as predicted from the model data while Figure 2 gives horsepower versus speed. The hollow in the curve between about 10.5 and 12 knots is characteristic of catamaran hulls although the actual location of the hollow is a function of demi-hull spacing. The hollow is caused by favourable wave interference between the hulls. From this point of view, the current

service speed of 12 knots is optimal since the vessel is operating at the right side of the resistance hollow. It is too late to experiment with hull spacing on the Sea-Bus and it is obviously nearly optimal as built (for 12 kn service), but it would be very desirable to experiment with hull spacing in similar future designs to attempt to place the resistance hollow at the design service speed. Figure 2 is the effective power curve for the Sea-Bus as derived from the resistance curve of Figure 1. In this graph, the "hollow" is less pronounced due to the introduction of speed into the ordinate variable to obtain power. Finally, Figure 3 is a graph of specific resistance versus non-dimensionalized speed. This curve may be used to compare approximately the efficiency of the Sea-Bus hull to that of the catamarans of similar size. It should not be used to compare to vessels much bigger or smaller, since the frictional component of total resistance would not be the same proportion of the total for such vessels.

There is very little published resistance data for catamarans so it is difficult to compare the performance of the Sea-Bus to that of other similar vessels. The writer is not familiar with another vessel be it monohull or multihull, which plys a similar trade in terms of length of run, passenger volume and schedule. Therefore, it is difficult to make a quantitative statement about the "goodness" of the Sea-Bus' hull design. The best that research has turned up to date is Figure 4 taken from the paper by Turner and Toplin, showing specific residuary resistance as a function of speed (non-dimensionalized). We have added the Sea-Bus model data to the graph with the interesting results shown. (As an aside, we note that specific residuary can be compared in this way for vessels of all sizes since wave-making resistance is essentially independent of the length-dependent Reynolds number).

Figure 4 shows the wave-making resistance of the Sea-Bus is proportinally much higher than that of either of the vessels described by Turner and Toplin up to Froude number about 0.343 but at Froude number 0.357, it has dropped below either of the other vessels' values. As previously explained, this can be attributed to favourable wave interference between the hulls and the effect results in the wave-making resistance of the Sea-Bus being as good on either side of the other vessels in the operating range, but much worse below. Therefore, on the basis of this very small data sample, the Sea-Bus appears quite efficient at low cruising speed, but one would wish for more consistent performance throughout the speed range.

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17. Abstract

This report is the second of a two-volume study dealing with Sea-Bus technology in Vancouver, B.C. Volume One provides a complete documentation of the technologies utilized in the Sea-Bus vessels and terminals. Volume Two addresses Sea-Bus impacts for the following areas: transportation, economics, urban development and harbour environment.

Sea-Bus performs a heavy commuter function bringing people who live on the North Shore to their work place in Vancouver's central business district. The major travel impact of Sea-Bus is more a function of its unique characteristics as a marine link and its quality of service. Sea-Bus impacts on reducing automobile traffic on the two bridges have been minimal and seven buses were removed from the Lion's Gate Bridge subsequent to its introduction. Harbour traffic and the marine environment have not been affected by Sea-Bus operations. A small proportion of commercial and business developments on the North Shore can be attributed to Sea-Bus.

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17. Résumé

Ce rapport est le second d'une étude en deux tomes concernant l'utilisation de la technologie du Sea-Bus à Vancouver, C.B. Le Tome I rassemblait une documentation complète des caractéristiques techniques du Sea-Bus et des terminus correspondants. Quant au Tome II, il étudie l'impact direct et indirect du concept dans les domaines suivants: transport, économie, urbanisme et environnement portuaire.

Le Sea-Bus sert aux migrations alternantes des usagers habitant la rive-nord, facilitant leurs déplacements vers le lieu de travail au Centre-Ville de Vancouver. L'intérêt de ce concept réside surtout dans ses caractéristiques uniques et dans la qualité du service qu'il offre. L'influence qu'il a pu avoir sur la densité de la circulation automobile, empruntant les deux ponts, a été marginale: sept autobus ayant été retirés du parcours depuis la mise en service. Ni la circulation, ni l'environnement portuaire n'ont eu à subir de contre-coup, tandis qu'une légère proportion de l'accroissement dans les activités commerciales de la rive-nord a été attribuée à ce véhicule.

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EXECUTIVE SUMMARY

The Sea-Bus is a unique urban ferry service. It has operated since 1977 across Burrard Inlet between the cities of Vancouver and North Vancouver. This system was examined to determine and evaluate its impacts in the areas of: transportation, economics, urban development, and harbour environment. It was found that the major and probably more important travel impacts of Sea-Bus are a function of its unique characteristics and quality of service.

Sea-Bus passengers incur longer travel times in comparison with the bus and automobile alternatives for the same trip. It appears that Sea-Bus passengers are willing to spend more travel time just to use the service. This suggests that some of the special attributes of Sea-Bus attract some passengers for reasons other than trip expediency. They relate to the level of service and ride quality. Sea-Bus has always provided a reliable service. Seating is assured at all times and the vessel interior is spacious. In addition, the harbour view and uninterrupted journey enhances the ride experience.

Sea-Bus ridership includes a significant tourism component. It is also tending to enlarge the Vancouver CBD to include parts of the North Shore. Sea-Bus constitutes a small, but significant component in the development of Lonsdale Quay on the North Shore. Some of the retail and entertainment facilities that have developed around the North Shore terminal are in part attributable to the ferry service.

The Sea-Bus operation provides an important commuting facility. It carries 7% of the peak hour traffic across the Inlet and 5% of the daily traffic. It has also had a significant impact of public transit services across the Inlet. Seven buses (from 28 to 21) were removed from the Lions Gate Bridge in one peak hour as a result of Sea-Bus. This has helped to alleviate bus congestion at some Downtown Vancouver bus stops. Sea-Bus only contributed marginally (1%) to a reduction in automobile traffic on the two bridges.

The introduction of the ferry service, and the concurrent release of seven buses in trans-inlet service, presented the opportunity to re-design the North Shore bus route network. As a result, the North Vancouver bus service has been extended to serve new routes and service frequency has been increased along with improved transfer connections.

It appears that Sea-Bus has not been a cost efficient alternative to the bus system. This situation will probably improve when Sea-Bus operates at full capacity which would require the addition of six ferries over the two presently in use. The infrastructure in place now can accommodate up to eight vessels, and can be operated without any additional staff. Moreover, the special quality of Sea-Bus is unlike typical bus service and this is reflected in the cost of the operation.

The impact of the ferry system on the marine environment has been negligible. Sea-Bus operations in the harbour has not affected the safety of other vessels or float planes using Burrard Inlet.

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1.0 INTRODUCTION

In 1974 the British Columbia Government decided to establish, as a third crossing of Burrard Inlet, a passenger only link between the North Shore and the City of Vancouver. The ferry service was to be integrated with the overall transit system and serve as an alternative mode in replacement of buses and private cars using the bridge routes. The base capacity of two ferries was selected as being equivalent to one lane of the Lion's Gate Bridge given the rush hour traffic at that time.

In June 1977 Sea-Bus started operation, providing a unique form of transportation for commuter movement across the Inlet. The ferry route, in a regional context, is shown in Figure 1.

1.1 Purpose

Since the Sea-Bus concept was initiated in 1974, and commencement of services in 1977, enough time has elapsed for the effects of the system to manifest themselves. Some of the effects have been anticipated such as changes in transportation, etc., while others are spinoffs resulting from the establishment of the service.

The purpose of this report is to evaluate the impacts of the Sea-Bus system on transportation, economics, urban development and harbour operations for international and national dissemination. Each of these issues is discussed separately.

The Sea-Bus impact program was initiated in 1982 to evaluate the effects of the system from the time operations began in 1977 until 1982. The Transportation Development Centre and Transport Canada's Energy Research and Development Program provided funding for the study.

1.1.1 Approach

The basic approach taken for Sea-Bus study was to address a variety of impacts related to the introduction of a rather unique transportation system. Impact assessment studies of waterborne ferry transit are almost non-existent. The approach taken for the Sea-Bus study, however, is fairly common.

Impact Studies

The findings of a literature review suggest that the scope, attitudes and approaches used on assessing transportation projects have varied considerably over the past thirty years. It is also evident that there is some confusion as to what is implied by the impact assessment.

Highway and traffic oriented studies predominate over other modes of transport. The dominance is due primarily to the rapid growth in the automobile industry after World War II and the corresponding need for

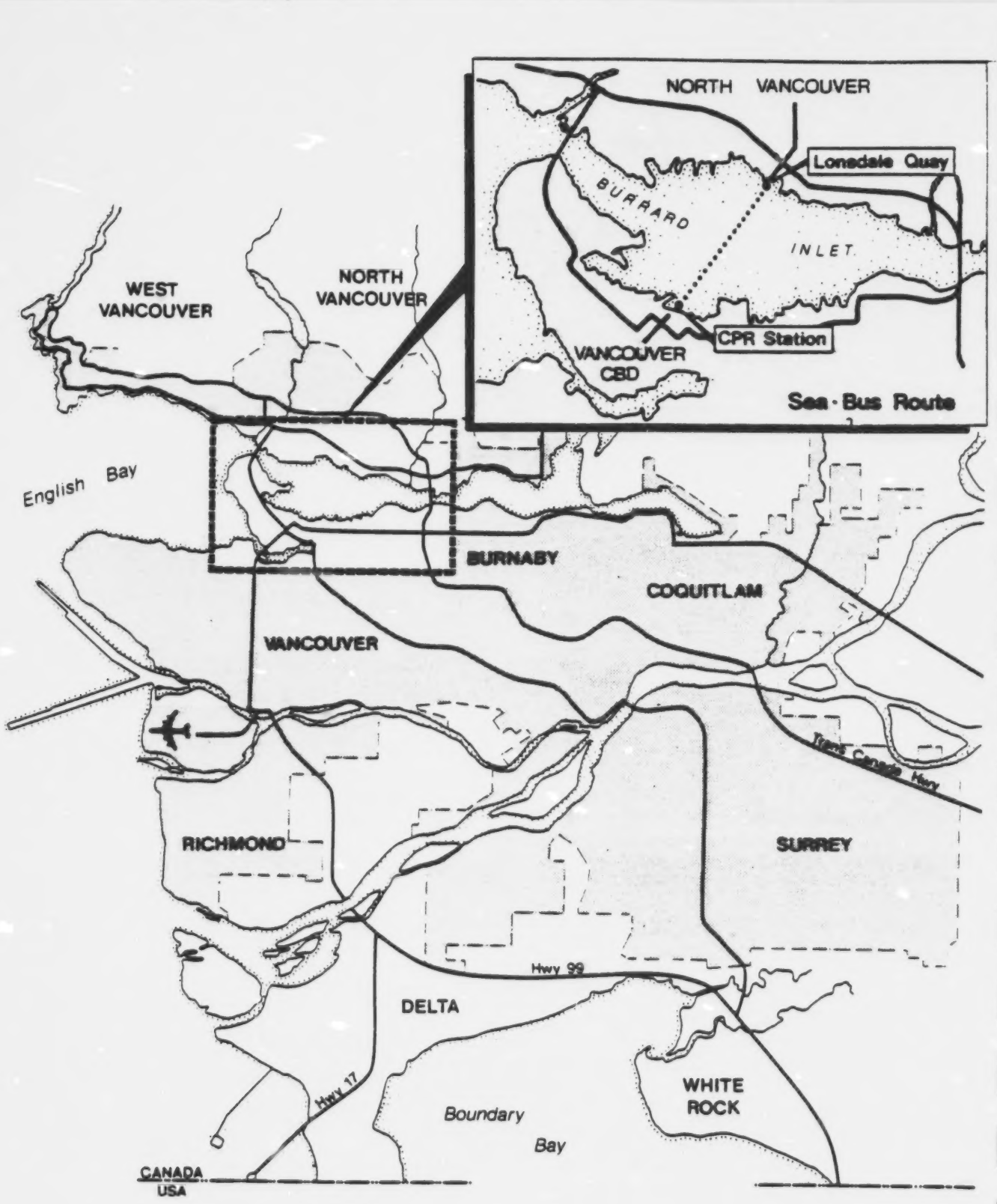


Figure 1

Sea·Bus Regional Context

bigger and better roads. The development of the United States interstate freeway system was a direct result of this trend.

Furthermore, most of the impact studies completed to date are in relation to the United States transportation experience. Canada, though somewhat delayed in their concern for impact assessment, followed suit as the Trans-Canada Highway took shape during the fifties and sixties. The pioneering efforts in the area of impact analysis were therefore concentrated in the United States.

The development of the interstate freeway system in the post war years provided the foundation for the earliest assessment studies. The initial approach was to address the impacts of a number of highways that were completed or near completion. This approach to impact analysis is still popular. Forecasting transportation impacts and impacts concerning local issues are also common approaches. There are very few comprehensive studies that deal with a broad range of impacts both before and after the development of a transportation project.

During the fifties when interstate highways were receiving considerable attention it was feared that many towns and cities would suffer serious (at least significant) economic losses due to the bypass concept of freeway design. As a result, impact studies were commissioned to look specifically at the economic effects, including land use and land value effects.

The first generation of impact studies were conducted after the planning and design of transportation projects. In most cases, however, impacts were addressed following the construction phase. Such studies reflected two basic approaches. The first presented the view that the highway, etc. was necessary and that the long term benefits would outweigh the adverse affects. The second approach encompassed a broader perspective. It not only looked at immediate economic effects and local effects near the new transportation project, but attempted to view the changes in a regional context. The latter studies, although not comprehensive, were the best studies undertaken at the time.

By the late fifties impact studies incorporated economic issues. These impacts were measured by comparing the study area with a similar 'control area' which differed essentially by its lack of a major transportation change such as an interstate freeway bypass.

In the sixties environmental concerns related to noise, air quality, visual intrusion and ecological quality (effects on flora fauna and water) began to reach provincial/state and federal legislatures. More often than in the past impact studies were initiated in the

planning and design phases and concluded by measuring actual impacts after construction was complete. This permitted more comprehensive approaches to impact evaluation. This type of approach is seen in Canada - U.S. Alaska highway project. The project brought together a team of highway designers and environmentalists to develop a comprehensive plan for a 520 km highway in the delicate and spectacular Yukon-Alaska corridor.

It was not until the 1970's, and the advent of environmental legislation, that impact statements were manditory for any federal or provincial/state funded transport projects. In the U.S. the tendency was towards a separation of transport or highway and environmental agencies. The environmental decisions would often override highway decisions causing expensive project delays and strained relations between co-operative agencies. In recent years, however, there has been a move by provincial and state governments to integrate environmental planning within the transport or highway agency. This approach and reorganization has lessened environmental advocacy but has streamlined the planning and design process.

The comprehensive impact assessment for transportation projects is still a rare occurrence. The general trend is for government agencies to commission studies that deal with only environmental issues or with only economic (land use and urban development) issues. The major exception has been the mammoth BART (Bay Area Rapid Transit) Impact Program (BIP) in the San Francisco - Oakland Region. This study began after the transit system was implemented, however, the subject of anticipated impacts was incorporated into the designing and planning of BART.

BIP was intended to be a medium term (1972 - 1979) comprehensive impact evaluation. The essential purpose was to discover what actual impacts are attributable to a large scale regional rapid transit system serving a major metropolitan area. The study has uncovered many myths about transport facility impacts which is now being adopted in current rapid transit planning and marketing such as Vancouver Advanced Rapid Transit (ALRT) project.

The brief history of transport facility impact evaluation indicates that much has been discovered in the complex relationships between transportation networks and the institutions and habitats they interconnect. The public and government have discovered that significant changes in transportation mean more than reduced transport costs and travel time to users. This has been demonstrated by the integration of impact analysis in transport design and the wide scope of impact issues being studied.

1.1.2 Evaluation Scheme

The evaluation scheme outlined below shows the procedures taken for the study. The initial step was to gain an understanding of the

trans-inlet transportation system and the basis for Sea-Bus. This provided the background for identifying possible areas of impacts.

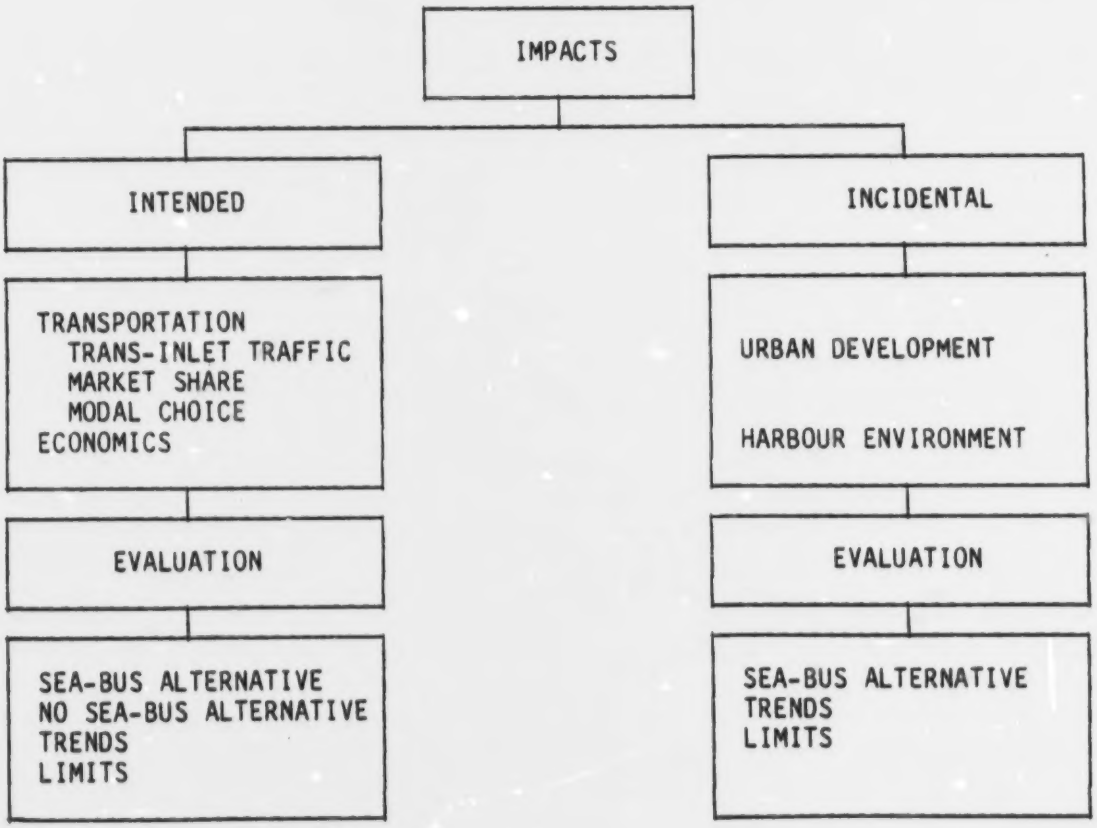
The subjects examined for the study have been organized into two general categories. The "intended" category relates to the anticipated areas of Sea-Bus impacts. The unexpected spinoffs of the system comprise the "incidental" impacts.

The no Sea-Bus alternative provided a baseline guide to measure transportation and economic impacts. A time series methodology was used for analysis of urban development trends prior to and following Sea-Bus implementation. The effects of Sea-Bus and its facilities on the marine environment during the construction phase and following operations were examined. Sea-Bus operations is a busy port situation were also investigated.

The evaluation process was largely governed by the information available. Since the implementation of Sea-Bus, there has been no systematic approach to data collection for establishing a reliable set of time series statistics for the purpose of identifying baseline conditions and trends. Much of the existing information is widely dispersed among various agencies. In many cases there are gaps in the information.

Much of the data used for the analysis was collected from administrative and general statistical sources. This resulted in the use of less powerful techniques of analysis, particularly for the evaluation of incidental impacts.

EVALUATION SCHEME



1.2 Background

In this section the historical ferry service on Burrard Inlet is described followed by an outline of the sequence of events leading to the establishment of Sea-bus. Finally, a brief description of the existing Sea-Bus system is given.

1.2.1 Historical Ferry Service

The provision of ferry transit across Burrard Inlet is not a new idea in local transportation planning. The first ferry service from Vancouver to the foot of Lonsdale on the North Shore was introduced in 1894. The operation played a prominent role in the early development of Lower Lonsdale, influencing its growth as a commercial centre and providing a major gateway to North Vancouver.

In 1907 the City of North Vancouver assumed responsibility for the ferry system and operated it as a joint stock company known as North Vancouver Ferries Limited. The service was retained when the Lions Gate Bridge opened in 1938 but was discontinued prior to the opening of the Second Narrows Bridge in 1960.

Before the ferry service ended, Lower Lonsdale was well established as the economic, transport and social focus for North Vancouver. This was attributable to the development of activities in the vicinity of the ferry terminal and along the P.G.E. Railway line. With the discontinued service came the end of nearly all public use of the central area of North Vancouver's waterfront.

1.2.2 The New Ferry Alternative

The initial decision to introduce the Sea-Bus transit idea was founded on a government public tranportation policy statement issued in 1973. The policy objectives focussed on the need to provide public transit in various communities in British Columbia, including the benefits of transportation facilities to communities.

The benefits of the proposed program were seen as more efficient use of existing road space by increasing passenger capacity through the provision of public transit. The results of the efforts would be reduced dependence on private automobile use and relief of some pressure to build more highways, parking facilities and bridges while at same time, conserving land and maintaining liveability in the communities. For the first time transit planning was to be used as a positive tool in shaping development of communities.

To fulfill the stated policy objectives the Bureau of Transit Services was established under the direction of Municipal Affairs. As its basic function, the Bureau was to plan and administer transportation programs within the province.

The Sea-Bus ferry system constituted a segment of this program. The decision to introduce the ferry alternative was based on the need to

develop additional passenger service between North Vancouver and the City of Vancouver. The bus system in service at the time was considered insufficient to meet the settlement pattern needs on the North Shore. This would have required 15 additional buses. The view was taken that increased bus service would contribute to congestion on the two bridges and on the streets at bus stops in Downtown Vancouver.

The ferry alternative also presented an immediate course of action for providing additional passenger capacity across the Inlet and replanning the North Shore bus network. In keeping with the stated transportation policies, the community of North Vancouver would benefit from the system through the provision of increased accessibility without any increases in road traffic and land consuming traffic facilities.

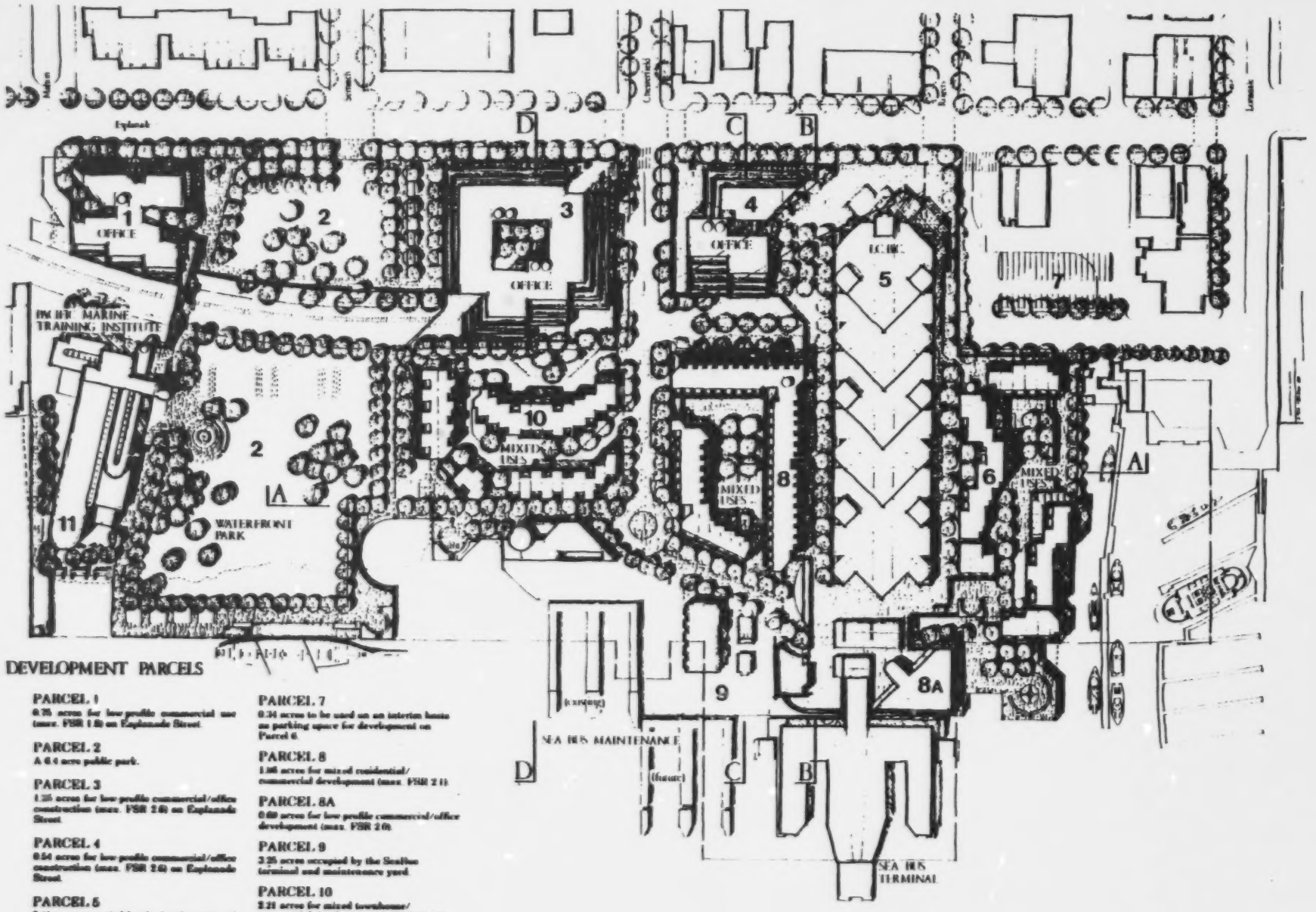
In addition to resolving this transportation issue, the Sea-Bus concept offered a unique opportunity for the development of an innovative system in British Columbia, with possible market prospects.

In consideration of the numerous benefits that could be derived from the development of the Sea-Bus system, the government immediately proceeded with its implementation.

The initial design specifications and requirements were outlined for the vessels and terminal facilities. Case Existological Laboratories (CELL), a naval architect firm, was selected to design and construct the entire system of terminals and vessels in accordance with the specifications. Moreover, appropriate sites for the location of a terminal on each shore line were selected.

On the North Shore the site was chosen at the foot of Lonsdale Avenue, near the location of the previous ferry wharf. Land acquisition was carried out in 1974 under an expropriation Order in Council for consolidation of 12 hectares of land within the vicinity of the present Sea-Bus terminal site. The land assembly involved negotiations with a number of private agencies, the municipality and the National Harbours Board. Many of the then existing industrial firms were relocated or ceased operations (refer to Appendix A).

Subsequent to the acquisition procedure these properties were handed over to the British Columbia Development Corporation for management and development of Lonsdale Quay. As illustrated in Figure 2, the entire project is being constructed within a five year (1980-1985) implementation program. Lonsdale Quay comprises a mixed use redevelopment project on the Lower Lonsdale Waterfront. At present nearly half of the project is completed, including the buildings for the Marine Institute of Technology, British Columbia Railway, the Insurance Corporation of British Columbia and the Sea-Bus terminal facilities.



DEVELOPMENT PARCELS

PARCEL 1
0.35 acres for low profile commercial use (max. FSR 1.0) on Esplanade Street.

PARCEL 2
A 0.4 acre public park.

PARCEL 3
1.35 acres for low profile commercial/office construction (max. FSR 2.0) on Esplanade Street.

PARCEL 4
0.54 acres for low profile commercial/office construction (max. FSR 2.0) on Esplanade Street.

PARCEL 5
3.41 acres occupied by the headquarters of the Insurance Corporation of British Columbia.

PARCEL 6
1.71 acres for mixed residential/commercial use (max. FSR 2.0) in a "village" environment.

PARCEL 7
0.34 acres to be used on an interim basis as parking space for development on Parcel 6.

PARCEL 8
1.86 acres for mixed residential/commercial development (max. FSR 2.0).

PARCEL 8A
0.80 acres for low profile commercial/office development (max. FSR 2.0).

PARCEL 9
3.25 acres occupied by the SeaBus terminal and maintenance yard.

PARCEL 10
2.21 acres for mixed townhouse/commercial development (max. FSR 1.0).

PARCEL 11
1.70 acres occupied by the Pacific Marine Training Institute.

Figure 2

Lonsdale Quay Development Project

It is important to mention that at the time this site was designated as a major transportation centre consisting of ferry facilities, a bus-transit centre and a passenger rail centre.

The South Shore ferry terminal site at the foot of Granville was selected for its particular relation to attendant facilities and other existing and proposed transit facilities. Similar to the original North Shore transportation scheme, the terminal ferry facilities on the South Side formed part of a conceptual plan for future transportation centre on the Granville waterfront. Facilities for ferries, buses, light rail, commuter train and passenger train were proposed for the immediate area of the CPR Station.

The arrangements made for the introduction of the south terminal again involved the National Harbours Board as well as major private concerns (refer to Appendix A).

1.2.3 Existing Sea-Bus System

The main components of the Sea-Bus system are: the ferries, the floating passenger terminals, the North Shore bus loop, the South Shore elevated walkway to bus transfer or dispersal points, the floating servicing berths and the shore based maintenance and administration building. Without any additional facilities the system can be expanded to accommodate eight ferries.

The two ferries presently in use are all aluminum double-ended catamarans. The catamaran design was selected primarily for its outstanding maneouverability. With this design it was possible to provide a large seating area on the main deck. The double-ended configuration reduces turnaround time and increases safety at the terminals since no manoeuvers are required. The aluminum construction is lighter in weight than steel and thereby reduces fuel consumption.

Each ferry is capable of holding 400 passengers on the main deck. They operate on the 3.25 km crossing at 15 minute intervals during weekdays and every 30 minutes on weekends and evenings. At a travel speed of approximately 11.5 knots the trip is completed in 12 minutes.

The E-shaped floating passenger terminals have been designed to accommodate tidal variations of six meters. These concrete structures are held in position by buttresses and dolphins and are connected to land-based facilities by a hinged gangway ramp. Their design is compatible with the vessels to ensure safe and rapid passenger loading and unloading as well as precise vessel control while docking. The E-shaped design provides two embarkation areas on either side of the centre finger, each of which is capable of accommodating 400 passengers. The outside fingers provide identical debarkation areas. With this arrangement two ferries can be loaded and unloaded simultaneously.

The North Shore terminal occupies a portion of the Lonsdale Quay site. This area is immediately south of Upper Lonsdale, the central commercial and retail district of the City of North Vancouver.

The floating terminal is integrated with a sheltered walkway which connects to a covered bus loop. This bus node was established in conjunction with other Sea-Bus facilities to co-ordinate the North Shore bus system with the ferry service. Many North Shore buses were re-routed to the loop for this purpose. This bus loop will be relocated on the same site, but underneath the ICBC building which is near completion.

To the west of the floating terminal servicing berths and a maintenance and administration building forms part of the Sea-Bus facilities on the North Shore site.

The South Shore terminal, located adjacent to the CPR rail yards, is on the northern edge of the Vancouver CBD. The off-shore floating structure is fully integrated with land-based facilities consisting of an escalator enclosure which leads to an elevated walkway. The walkway extends over the railyard and connects to the CPR station concourse. At the station on-street access is gained through one of the many exit doors. Bus service is available on Cordova Street. It takes about 10 minutes to walk to the centre of most business, shopping and entertainment activity in Downtown Vancouver.

2.0 TRANSPORTATION

One original objective of the Sea-Bus was to provide trans-inlet service which would in some degree alleviate future traffic congestion on the First Narrows Bridge (Lion's Gate) and Second Narrows Bridge. As an additional function the Sea-Bus was to provide an alternative mode in replacement to private vehicles and transit systems using the trunk routes. The service was further intended to reduce bus congestion at bus stops along streets in Downtown Vancouver.

This part of the study focuses on the transportation component of Sea-Bus to determine its impacts on trans-inlet traffic in keeping with the original objectives, and on transportation changes made as a result of the introduction of a new transit ferry link. It also reviews the less obvious impacts of Sea-Bus as a new alternative mode of transportation.

To examine the impacts of Sea-Bus on the overall transportation system, this part of the study has proceeded through two major stages of analyses. The initial step was to provide background information on the overall trans-inlet transportation system. This data formed the basis for the assessment of Sea-Bus impacts, the second stage of the analysis.

2.1 Background

This section includes traffic count data on the trans-inlet travel routes and the results of a Sea-Bus passenger survey. The traffic count information has been provided to measure the magnitude of Sea-Bus traffic in the overall trans-inlet traffic system. The survey was initiated to reveal any traffic system demand changes in modal choice, etc., as a result of Sea-Bus.

2.1.1 Trans-Inlet Traffic

Trans-inlet traffic is divided into the following three major flow routes: First Narrows Bridge (Lions's Gate), Second Narrows Bridge and Sea-Bus. The following first examines traffic volume on the two bridges in terms of historical trends, seasonal, weekly and daily patterns. The modes of transport are auto and bus transit. Sea-Bus is also examined in a similar context. Then, the Sea-Bus market share of trans-inlet trips is estimated on the basis of the average daily traffic and peak period passenger loading.

Bridge Traffic Volume

Included under this heading are the annual trends, seasonal and daily patterns of traffic volume on the two bridge crossings. The traffic volume trends and patterns are based on permanent traffic counts obtained during the past decade.

Annual Trends

The traffic count data indicates that the traffic volume on the First Narrows Bridge has experienced little growth in the past 14 years. As shown in Figure 3, an average growth of 1.4% per year accounts for the daily traffic volume, both directions, on First Narrows. Traffic volume on the Second Narrows Bridge reflects a higher growth rate estimated at 3.5% per year since 1970 (refer to Figure 4). In the past three years, however, the traffic volume on both bridges has remained constant or slightly declined. This change is probably the result of the economic recession.

Seasonal Patterns

The monthly average daily traffic (ADT) patterns have been compared for the periods 1977, 1981 and 1982 (refer to Appendix B). The ADT figures show an increase in the overall traffic volume from 1977 to 1981 with a reduction in 1982. There are minor seasonal fluctuations in the traffic volume on both bridges. Slightly more traffic is generated across the bridges in the summer as opposed to the winter season.

Daily Patterns

The daily traffic patterns have been based on volume comparisons between January, April and October of 1977, 1981 and 1982. The data reveals similar seasonal variations in the hourly traffic patterns on both bridges. Only a slight overall volume fluctuation is observed in these periods.

The hourly southbound pattern on the First Narrows Bridge shows a substantial increase in traffic between 7 am and 9 am followed by a stable flow until the evening. The northbound traffic volume increases steadily from 7 am and reaches a peak between 4 pm and 6 pm. This pattern is clearly unimodal and in part reflects the limited capacity of the bridge with one of the three lanes being reversable.

Daily traffic volume data on the Second Narrows Bridge represents a distinctively different pattern in comparison to that of the First Narrows Bridge. On Second Narrows, the southbound traffic peak period occurs between 7 am and 9 am and repeats again around 5 pm. The afternoon peak duration is shorter than in the morning. The northbound traffic pattern is the reverse of the southbound pattern. In this direction the morning peak is considerably shorter than the evening peak period.

The hourly traffic volume on the two bridges on different days of the week have been based on comparisons between April 1977 and April 1981. The weekday patterns are similar and show distinct morning and/or afternoon peak periods. The weekend patterns do not represent any significant peaks.

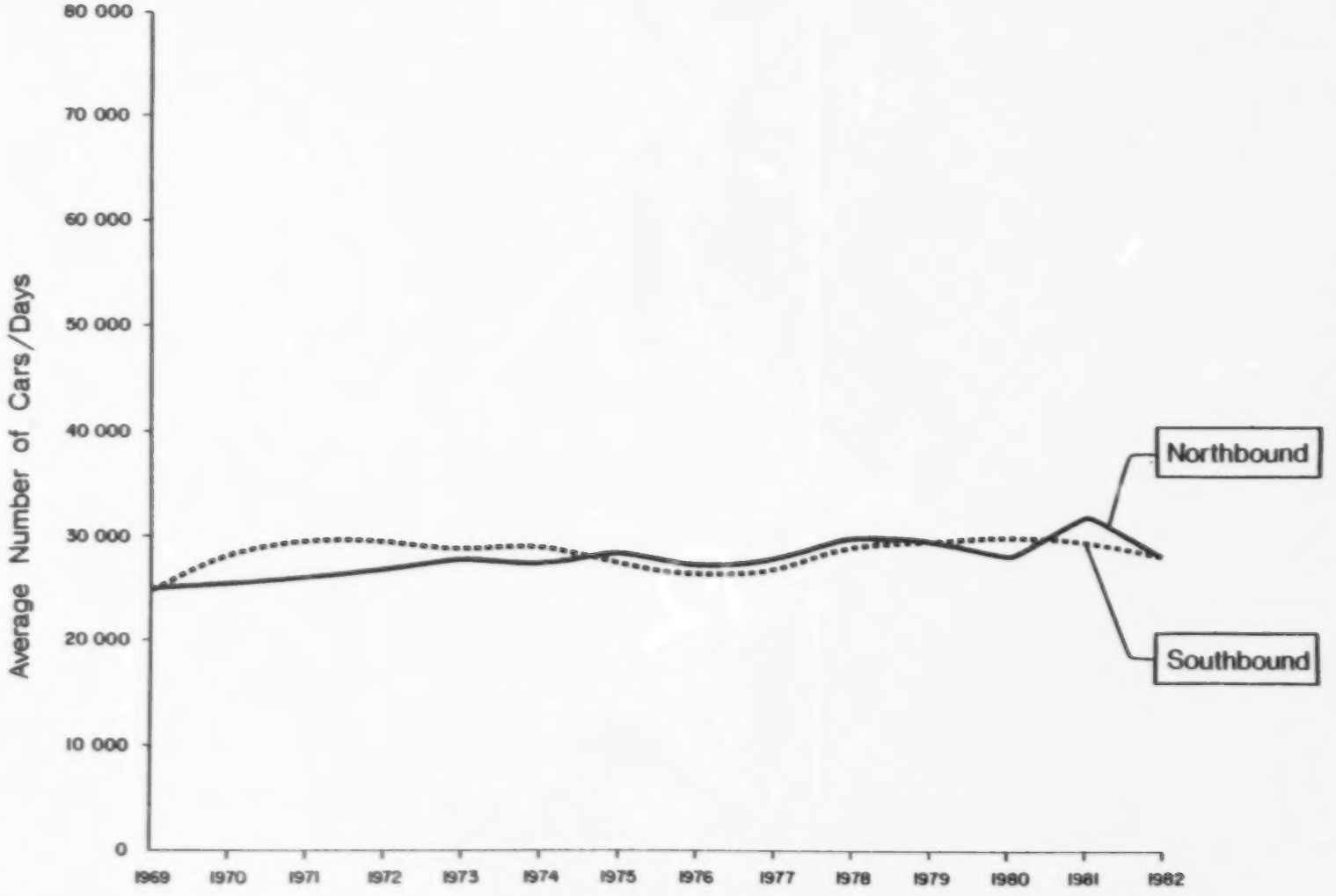


Figure 3

Traffic Volumes

FIRST NARROWS BRIDGE

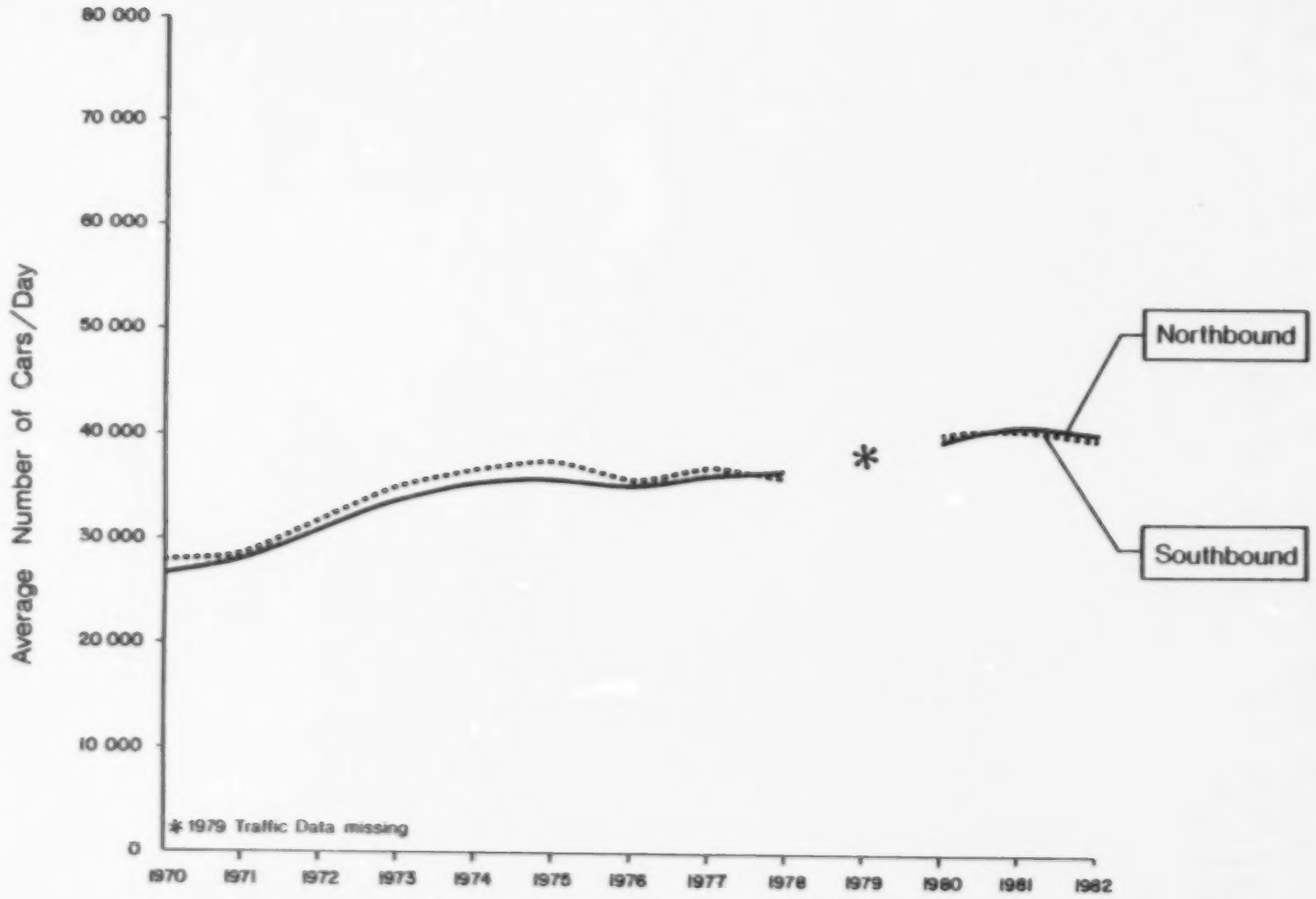


Figure 4

Traffic Volumes
SECOND NARROWS BRIDGE

Sea-Bus Ridership

The annual, seasonal, weekly and daily Sea-Bus ridership counts have been recorded on a daily basis since the start of the service. These counts provided the data for the following analysis of Sea-Bus ridership patterns.

Annual Trends

Since the start of the Sea-Bus operation in July 1977, the total annual ridership figures have remained relatively constant (refer to Figure 5). In the first month of operation (July) ridership reached over 435,000. This figure, in combination with 377,000 in August, represents the highest monthly ridership counts to date. This trend appears to be attributable to the trial rides of many first-timers and summer tourists. In March of 1978, the monthly ridership displayed the lowest level at 182,000 counts. The week-long strike in that month is the primary reason for the decrease in ridership.

The average annual daily passenger loads for the past five years has remained fairly stable at about 8,500 passengers. The annual growth rate from 1978 to 1982 of 0.5%, indicates a marginal increase in Sea-Bus ridership.

Seasonal Patterns

The seasonal ridership volume displays a similar pattern for each year in the five years of service. There is a general trend which indicates a reduction of extreme peaks and valleys as each new year of service has progressed. The patterns show a decline in ridership during the summer with a steady increase in the remaining seasons. The summer ridership pattern may be a reflection of fewer tourists using Sea-Bus as a result of the economic recession. The ridership counts in other seasons may be attributed to an increased usage of Sea-Bus as a regular transit mode, especially by commuters.

Weekly Patterns

The weekly ridership patterns are based on the month of April which is representative of an average month of Sea-Bus service. Figure 6 graphically illustrates the daily passenger volume for the month of April in the years 1978 to 1982.

The examination of the weekly ridership volumes reveals a substantial difference in the weekday and weekend patterns. During a typical week the Sea-Bus ridership pattern remains relatively stable from Monday to Thursday with a significant increase on Friday. Sunday ridership counts are consistently the lowest while the Saturday passenger volume is positioned between that on Sunday and the weekdays. It is important to note that Sea-Bus service operates less frequently on the weekends than on weekdays.

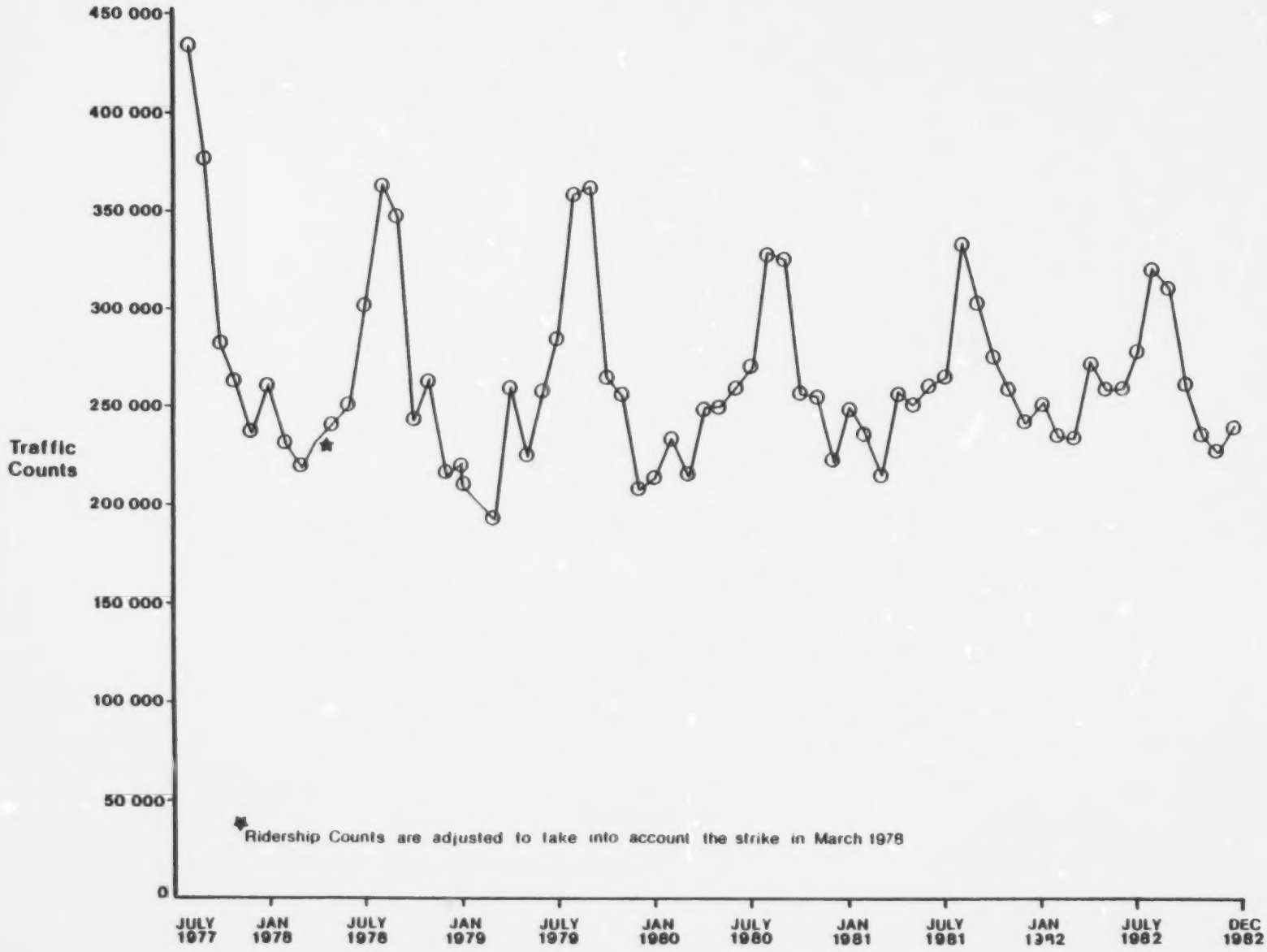


Figure 5

Sea-Bus Passenger Counts

July 1977 - December 1982

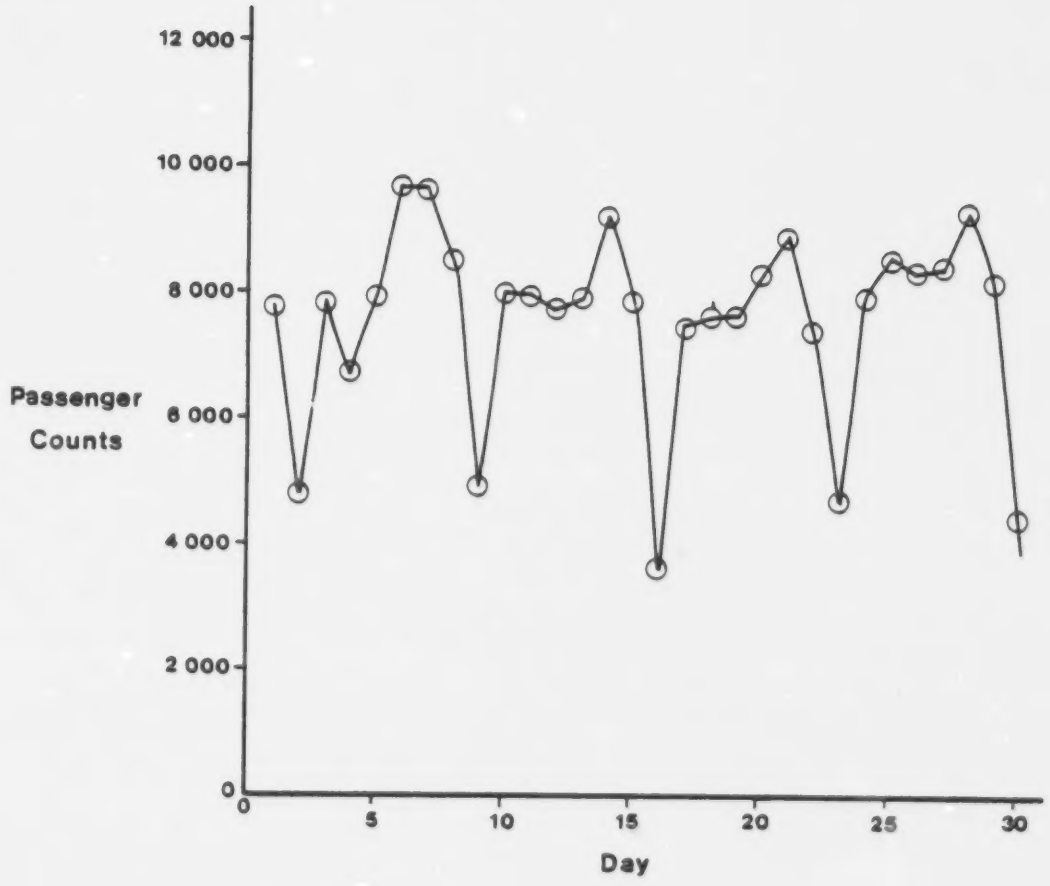


Figure 6
Sea·Bus
Average Passenger Counts
April 1978-1982

The deviations from the typical weekly pattern in April are attributable to the Easter weekends. As the graph illustrates, there are significant changes in the ridership counts from year to year during the Easter holidays.

Daily Patterns

Fluctuations in the daily ridership patterns have been examined by comparison of the hourly passenger counts during two typical weeks of Sea-Bus service. The two weeks, April 10 to 16, 1978 and April 6 to 12, 1981 were selected from the previous analysis of weekly patterns. Moreover, since the hourly passenger loadings are largely directional, passenger count statistics were aggregated by the hour of sailing time and by direction. Figures 7, 8, 9, and 10 show the hourly patterns according to the day of week.

The southbound sailing counts reveal a peak concentration in the 7 am to 9 am period during the weekdays. The peak period occurs between 4 pm and 6 pm for the northbound trips. The weekday ridership patterns show remarkable consistency in both directions.

In comparison to weekdays, the ridership counts for weekends are substantially lower and represent less conspicious peak periods in the middays. Southbound weekend peaks occur in the late morning and early afternoon. Northbound ridership reaches a peak in the late afternoon.

The main differences in the data for 1978 and 1981 figures are the higher ridership in the peak period in both directions in 1981, and lower weekend loading curve in 1981. These observations suggest that the role of Sea-Bus has been shifting away from a tourist attraction to a mode of transit for trans-inlet commuters.

Sea-Bus Market Share

The following examines the market share of Sea-Bus traffic in comparison to the competing modes. The Sea-Bus market share of the total trans-inlet person trips is represented separately for the average daily and peak hour periods.

Annual Average Daily Traffic

The Sea-Bus proportion of the daily trans-inlet person trips is given in Table 1. This Table provides an approximate comparison of Sea-Bus and bridge traffic volumes. The total Sea-Bus person trips are based on the annual average daily ridership counts. Permanent vehicle counts on each bridge have been used to calculate the annual average daily traffic volume. The vehicle counts, however, do not distinguish between bus transit and automobiles. The occupancy rates of these modes have been obtained from a one day screenline survey sample. The occupancy rates were then converted to person trips to estimate the passenger volume on each bridge.

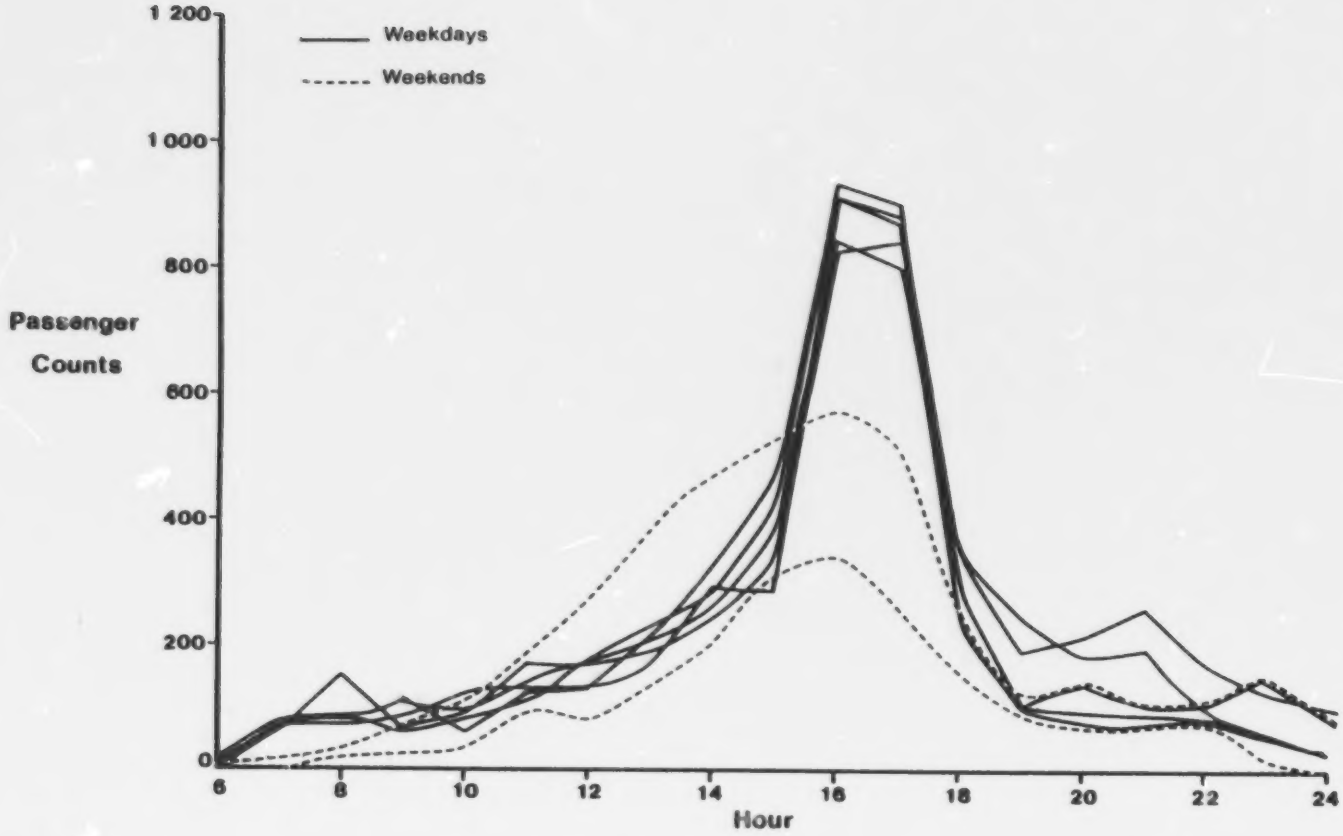


Figure 7

Sea-Bus Passenger Counts

Northbound - April 10-16,1978

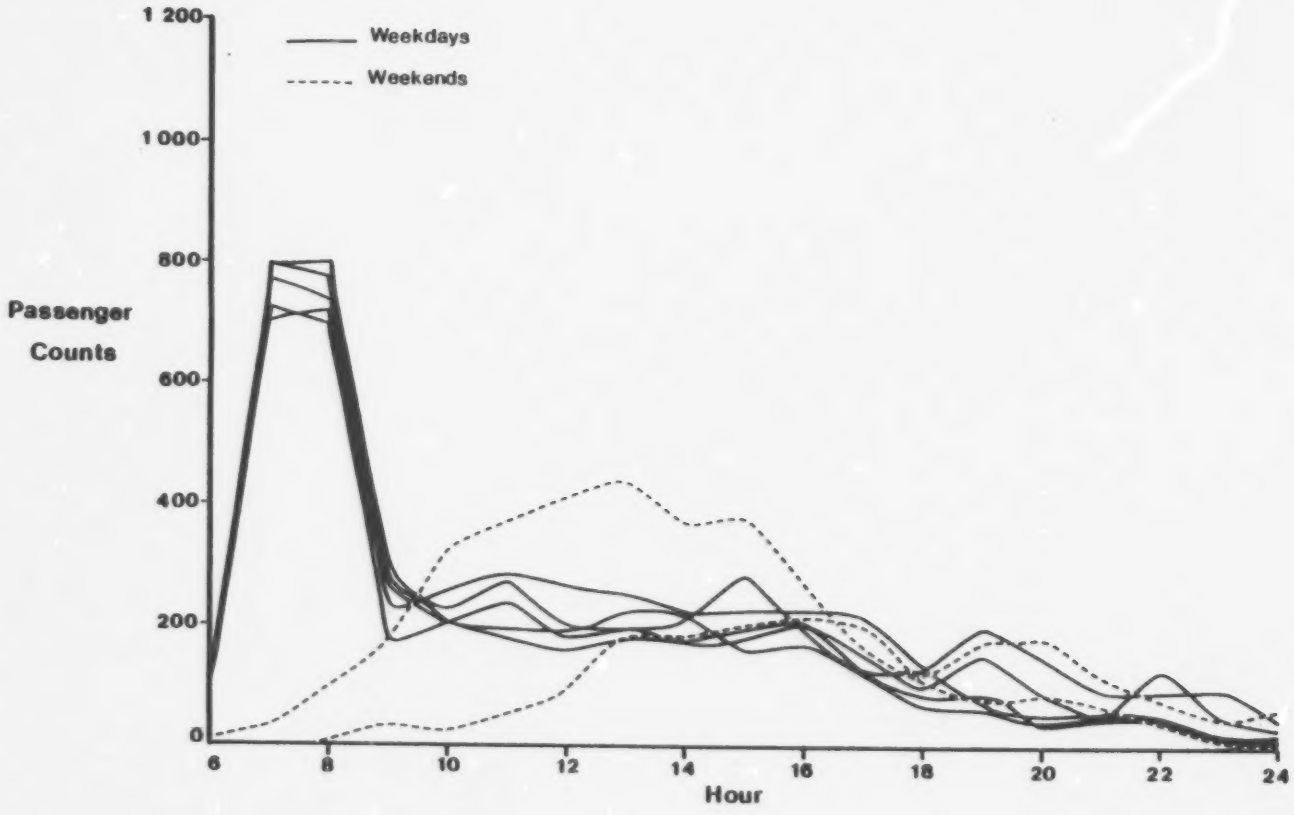


Figure 8

Sea-Bus Passenger Counts

Southbound · April 10-16,1978

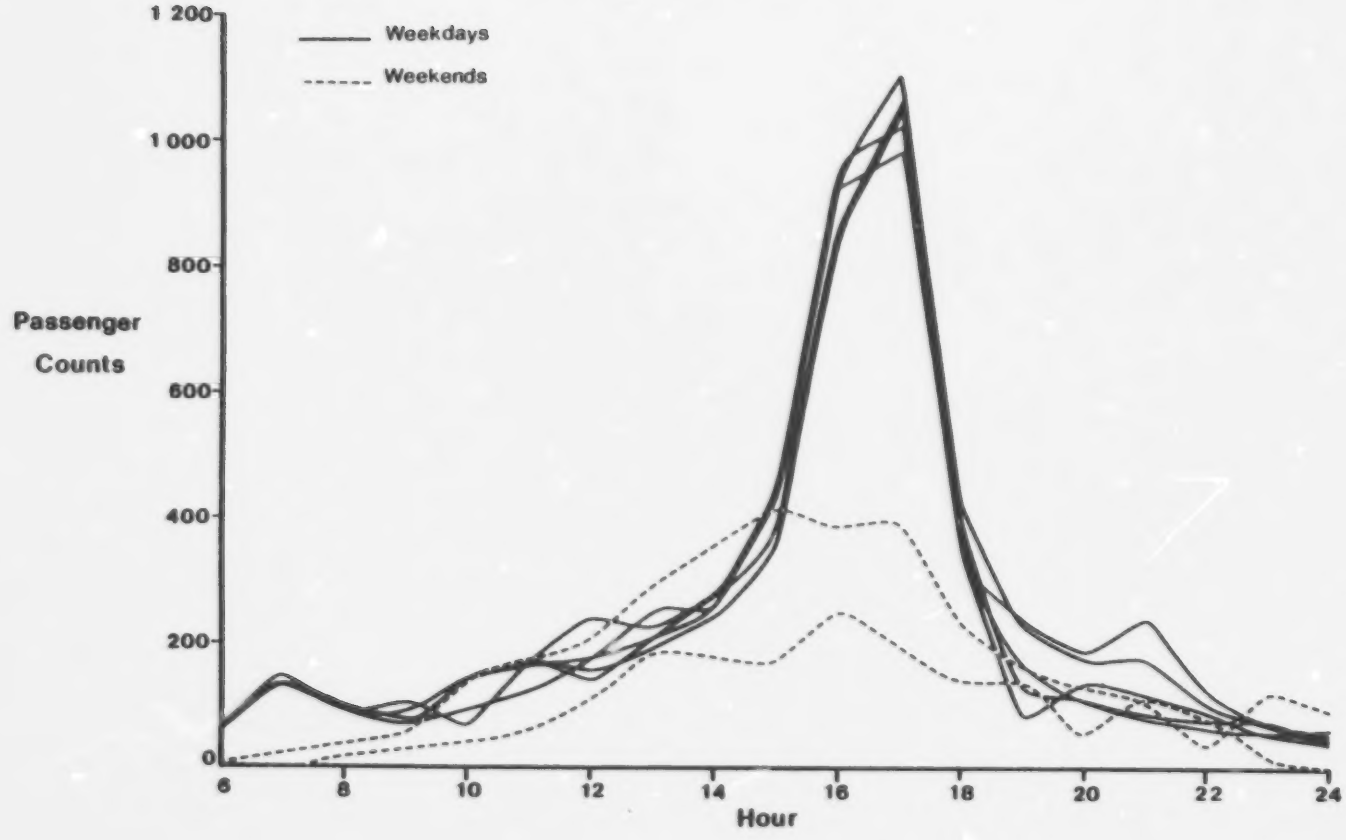


Figure 9

Sea-Bus Passenger Counts

Northbound · April 6-12, 1981

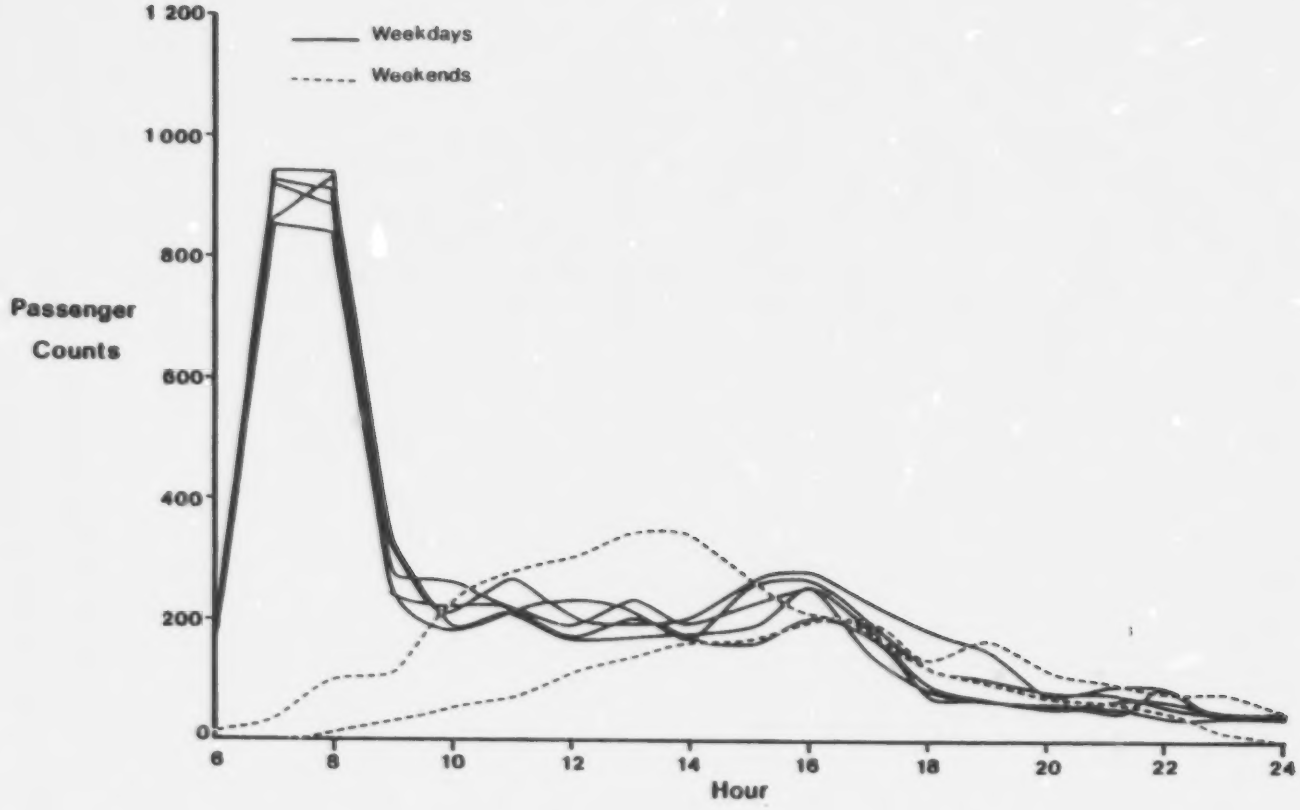


Figure 10

Sea-Bus Passenger Counts

Southbound · April 6-12, 1983

As shown in Table 1, the vehicle occupancy rates have been converted to person trips for the years, 1979 and 1982 to correspond with Sea-Bus ridership counts. The vehicle occupancy rate for the First Narrows Bridge is higher than that of the Second Narrows due to the higher transit traffic.

	First Narrows	Second Narrows	Sea-Bus
1979			
AADT*	58951	72563	
Occupancy Rate	1.33	1.24	
Pers. Trips	78405	89978	8500
Share (%)	44	51	5
1982			
AADT*	56269	80212	
Occupancy Rate	1.43	1.25	
Pers. Trips	80465	100265	8624
Share (%)	42	53	5

* Annual average daily traffic

Table 1. Sea-Bus Market Share of Daily Traffic

The estimated market share figures indicate a shift of the share from the First Narrows Bridge to the Second Narrows Bridge between 1979 and 1982. This change corresponds with the increased bridge traffic on the Second Narrows Bridge. The Sea-Bus market share, however, is stable at 5% for the annual average daily person trips across the Inlet.

Peak Period Loading

The Sea-Bus hourly ridership has been compared to passenger counts on the two bridges for the same time period. The hourly patterns suggest that Sea-Bus has a higher peak concentration of passengers than bridge traffic. In April 1981, peak hour passenger counts on the First Narrows Bridge represented about 12% of the daily total. The equivalent for Sea-Bus was over 20%. This general pattern of higher transit concentration during the peak period is commonly associated with public transit when compared to automobile traffic.

Table 2 provides an estimate of the Sea-Bus market share of trans-inlet person trips during the daily peak periods. The figures representing person trips on the two bridges are based on the screenline survey mentioned earlier.

Northbound	Peak period 16:00 - 18:00		
	First Narrows	Second Narrows	Sea-Bus
ADT* (April 1981)	6151	9667	
Occupancy Rate	1.86	1.34	
Pers. Trip	11441	12954	1955
Share (%)	43	49	7
Southbound	**Peak period 7:00 - 9:00**		
ADT* (April 1981)	7118	9651	
Occupancy Rate	1.72	1.25	
Pers. Trip	12243	12064	1800
Share (%)	47	46	7

* Average Daily Traffic

Table 2. Sea-Bus Market Share of Peak Hour Traffic

The proportion of Sea-Bus trans-inlet person trips accounts for 7.4% of the northbound traffic and 6.9% for southbound. The southbound figure is directly comparable to the results of a similar study completed in September, 1977. Although the comparison is based on one day in September 1977 and five days in April 1981, both periods closely represent the annual average ridership and are free from seasonal variations. It is therefore reasonable to conclude that the market share of Sea-Bus has remained relatively stable since the initial six month period of operations.

The Sea-Bus share during the peak period is higher than the daily share. This is expected because Sea-Bus, as a mode of transit, generally has a higher peak concentration than automobile traffic.

2.1.2 Sea-Bus Passenger Survey

The research program to assess Sea-Bus impacts included a passenger survey. The main intent of the survey was to generate insights into the demand side of Sea-Bus as a basis to determine its impacts on trans-inlet travel. The survey was specifically designed to:

- identify travel information about Sea-Bus passengers such as trip origin and destination, trip purpose, trip length, access and egress modes, previous modes and car availability.

- identify the Sea-Bus catchment area; and

. identify the socio-economic profile of Sea-Bus patrons.

The Sea-Bus passenger survey was administered on March 23 to 26, 1983. The questionnaire form was printed on both sides of a card. A copy of the form and results of each question are given in Appendix C. On the first day one was handed out to every second person entering the Sea-Bus terminals prior to the sailings. On the following days a form was handled out only to those patrons who had not previously completed one. Most passengers filled out a form on the first day which reflects the heavy weighting of the Wednesday sample.

Questionnaires were distributed between 7 and 9 am; 12 and 2 pm; 4 and 6 pm, on each weekday, Wednesday, Thursday and Friday. Surveys were also conducted on Thursday evening between 7 and 9 pm and on Saturday afternoon and evening (12 to 2 pm; 4 to 6 pm; 7 to 9 pm). To avoid duplicating the trip information, survey respondants were asked to report only one trip regardless of the number of trips they made by Sea-Bus.

During the four day survey period, turnstile counts were recorded as a control on the sample size return. The turnstile counts for each of the sailings are indicated in Table 3.

Approximately 8,150 questionnaires were distributed and about 5,500 were returned. A total of 37,674 persons used Sea-Bus during the survey period. The overall response rate accounted for 14.6% of the total passengers carried. The directional distribution of the sample response was 50.8% southbound, or a 50/50 split by direction.

In addition to the passenger survey on-board interviews were administered with a total of 145 passengers over the mid-day and evening periods. A copy of the interview questions is given in Appendix C.

This sub-section outlines the results of the Sea-Bus passenger survey. Information is provided on travel time, trip purpose, and trip origin and destination modes of Sea-Bus passengers. Also included is the market area served by Sea-Bus, a profile of the patrons as well as the users' impression of Sea-Bus service.

Much of the following analysis is based on the results of the Wednesday sample. The Wednesday sample population was the largest for any given day in the survey period. The Wednesday responses were therefore selected to display travel behaviour on a typical weekday containing a typical peak period (7 am to 9 am).

Travel Time

The survey contained two questions on travel time. One was based on the amount of time it took for the same trans-inlet trip prior to the introduction of Sea-Bus. The other concerned the origin-to-destination travel time across the Inlet using Sea-Bus for part of the journey.

	(Number of Passengers)				
	Surveyed Time Periods			Excluded or Not Surveyed	Total for Day
Day	7-9 am	12-2 pm	4-6 pm		
Wednesday	2,063	936	2,325	4,096	9,420
Thursday	1,960	1,113	2,423	4,782*	10,278
Friday	1,889	1,208	2,380	5,449	10,926
TOTAL	5,912	3,257	7,128	14,327	30,624
PERCENT DISTRIBUTION	(19.1%)	(10.6%)	(23.6%)	(46.7%)	(100%)

* Includes passengers surveyed on Thursday evening.

Table 3 Weekday Turnstile Counts

A significant number of the Wednesday sample population (62%) made the same trans-inlet trip before Sea-Bus was inaugurated. Of this group, 38.5% incur a greater overall time via Sea-Bus than previously. Those who incur less time represented 22.9% and 25.8% indicated the same time. Thus, for 64% of this group use of Sea-Bus requires an equivalent or greater amount of time compared to the previous modes.

Nearly all of the Sea-Bus passengers surveyed on Wednesday provided an estimate of their origin-to-destination travel times. Sea-Bus represented one portion of the entire trip. The travel times recorded are based on the difference between the starting time from home, work, etc. and the expected arrival time to home, work, etc. The reported starting and arrival times were often indicated to the nearest fifteen minute interval, particularly the expected arrival times.

The trip length distribution for the Wednesday sample of Sea-Bus passengers is shown in Figure 11. This figure clearly illustrates a clustering of responses at the 15, 30, 45, 60, 75 and 90 minute travel times. The smooth curve drawn on the graph is an estimate of the reporting bias of the sample.

The overall trip length distribution represents a mean of about 50 minutes. Table 4 gives the mean travel time by Sea-Bus according by trip purpose.

The travel results were further examined to identify how much time it takes Sea-Bus passengers to complete various stages of their trans-inlet trip. Access and egress travel times along with corresponding travel modes are shown in Table 5. The overall average mean of travel times implies that Sea-Bus patrons spend less time to travel from the terminal to a destination point than to arrive at the terminal from a particular place of origin.

The total trip time indicated for each access and egress category represents all portions of the trans-inlet trip including the 12 minute Sea-Bus crossing. Comparison of the access and egress times with the total trip times suggests that substantial walking and waiting is an inherent part of the trans-inlet Sea-Bus trip.

Trip Purpose

The travel function of Sea-Bus is reflected in the passengers reasons for using the service. All passengers surveyed were therefore requested to indicate their trip purpose for that particular Sea-Bus trip.

It has already been implied by the previous analysis of ridership patterns that Sea-Bus provides an important commuter service. This is further evident in the passenger survey results. The results

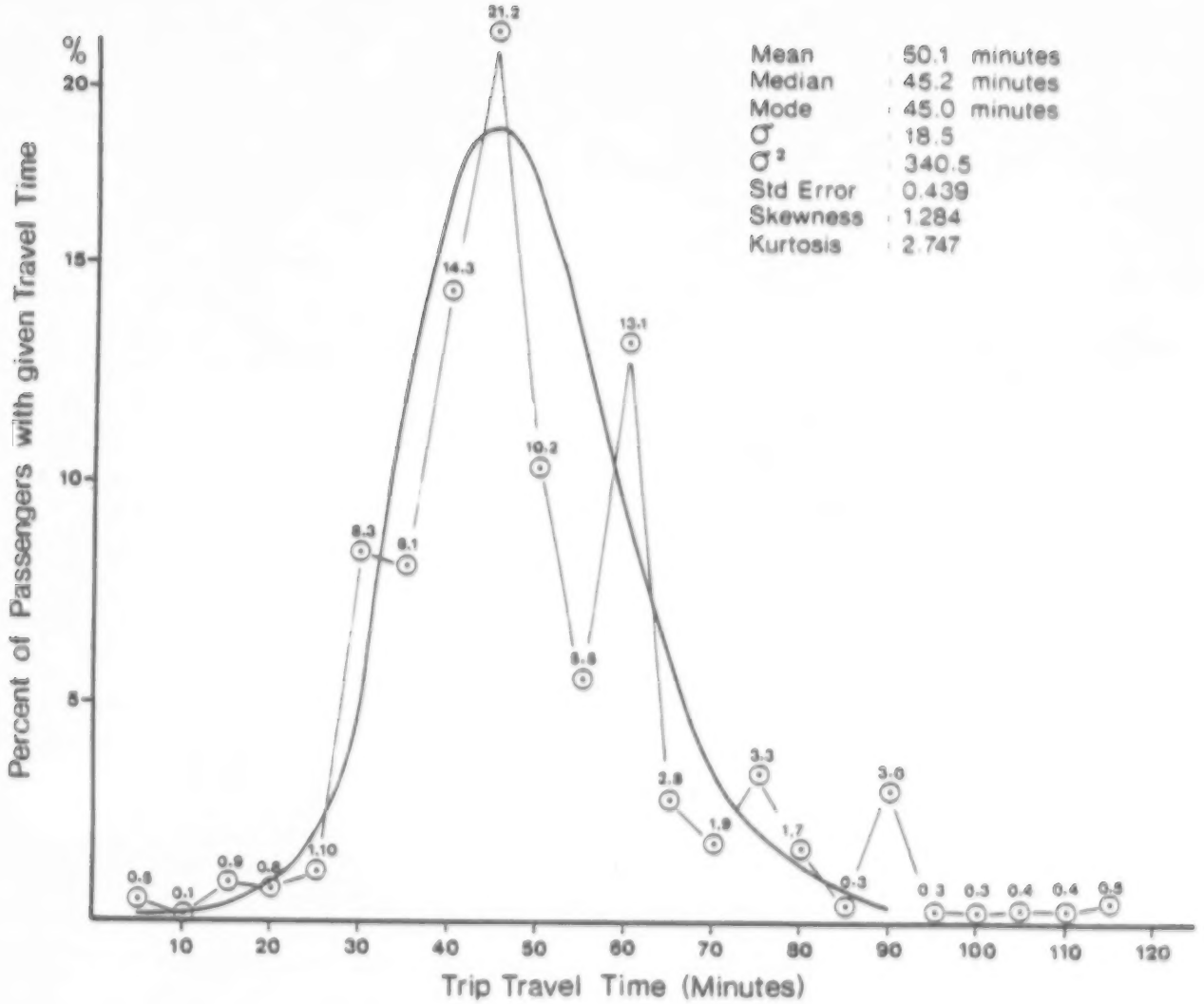


Figure 11

Sea·Bus

Trip Length

Distribution (Wednesday)

Trip Purpose	Mean Travel Time (Minutes) Trans-inlet Trip via Sea-Bus
Work	48.1
Shopping	49.3
Personal Business	56.9
Social/Recreation	53.2
School or College	59.7
All Others	54.4
Overall Mean	50.1

Table 4. Mean Travel Time by Trip Purpose

Mode	N	Mean Travel Time (Minutes) Access*	Total Trip	N	Egress**	Total Trip
Walk	384	21.2	49.3	607	11.0	46.0
Car Driver	56	18.9	42.8	24	29.8	55.7
Car Passenger	64	23.1	46.3	30	17.1	46.7
Bus, no transfer	376	24.4	49.7	251	20.3	51.9
Bus, with transfer	463	27.5	51.7	464	22.4	54.6
Car and Bus	24	37.5	63.2	7	28.0	60.3
Taxi	3	47.3	80.0	2	6.0	35.0
Other	49	28.3	55.3	58	18.9	53.7
OVERALL MEAN		24.7	50.2		17.1	50.1

* Access Time = Sea-Bus departure time - trip starting time

** Egress Time = Trip destination time - Sea-Bus arrival time

Table 5 Access/Egress and Total Travel Time by Mode (Wednesday)

showed that Sea-Bus also performs a special function for social recreational trip purposes.

Table 6 reveals that 23.6% of Sea-Bus patronage during the daytime hours occurs at the evening peak period with 42.9% in the two peak periods of the day. This pattern showing the evening peak higher than the morning peak is typical of an urban commuter transportation facility.

During a typical weekday, commuting to work (51%) by far comprises the most dominant Sea-Bus trip purpose, as shown in Table 6. Figure 12 provides a graphic illustration of Sea-Bus passenger travel in the morning peak period on Wednesday. The sample rate for this period constitutes 63% of the total passengers.

The heavy commuting to work function performed by Sea-Bus is clearly demonstrated in Table 7. The proportion of work trips at 69.0% is considerably higher for the Wednesday sample than the total combined weekday responses. Commuter traffic on Sea-Bus is also substantially higher than some typical average proportions for other studies. It is important to note that the comparison is between Sea-Bus, a transit facility serving a specific corridor, and studies which include the whole urban region and all other modes. The comparison does, however, illustrate the somewhat special commuting function of Sea-Bus.

In Table 8 the trip purpose responses for the 7 am to 9 pm period are indicated according to travel direction. As expected, the proportion of work trips at 86.6% is even greater during the peak period. The high concentration of southbound work trips is also expected.

The trip to school or college also comprises an important trip purpose during this period. About 4% of the total school (9.2%) trips are in the northbound direction.

The other trip purposes identified in Table 6 show social recreational (13.0%) as well as shopping (8.9%) as a significant proportion of all Sea-Bus trips. This Table also indicates clearly that Vancouver is the major destination for work and shopping trips. Social recreational trips, however, are more frequent towards the North Shore communities. School trips represent nearly equal directional splits. Trips to Capilano College in North Vancouver would account, in part, for this split.

The survey of Saturday travel given in Table 9 reveals the importance of Sea-Bus for social recreational trips, and to a lesser extent, shopping trips. Again the southbound shopping trips predominate, but social and recreational trips are almost evenly distributed by direction. Saturday travel on the Sea-Bus accounts for about 40% of the shopping, social and recreational trips represented in the entire survey period (refer to Tables 6 and 9).

Trip Purpose	Total Number of Passengers			
	Southbound	Northbound	Both Directions	
Work	1,597	642	2,239	(51.0%)
Shopping	264	128	392	(8.9%)
Personal Business	181	153	334	(7.6%)
Social/Recreation	226	347	573	(13.0%)
School or College	164	159	323	(7.3%)
All Others	130	408	538	(12.2%)
TOTAL			4,399*	(100.0%)

* Excludes non-response (Sample size = 4,483)

Table 6. Trip Purpose for Combined Weekdays (7 am - 6 pm)

Trip Purpose	SEA-BUS		VATS[1]	CATS[2]	NFTS[3]
	No. of Passengers	%	%	%	%
Work	1,369	(69.0%)	14.3	20.6	16.4
Shopping	87	(4.4%)	9.0	5.5	11.2
Personal Business	86	(4.3%)	8.1	10.2	6.7
Social/Recreation	102	(5.1%)	11.5	12.8	11.2
School or College	151	(7.6%)	9.2	1.9	2.9
All Others	191	(9.6%)	47.9	49.0	51.6
TOTAL	1,986*	(100.0%)			

1. Vancouver Area Transportation Study, 1973
2. Chicago Area Transportation Study, 1960
3. Niagara Frontier Transportation Study, 1962

* Excludes non-response (Sample size = 2042)

Table 7. Daily Trip Purposes Compared with Other Studies (Wednesday)

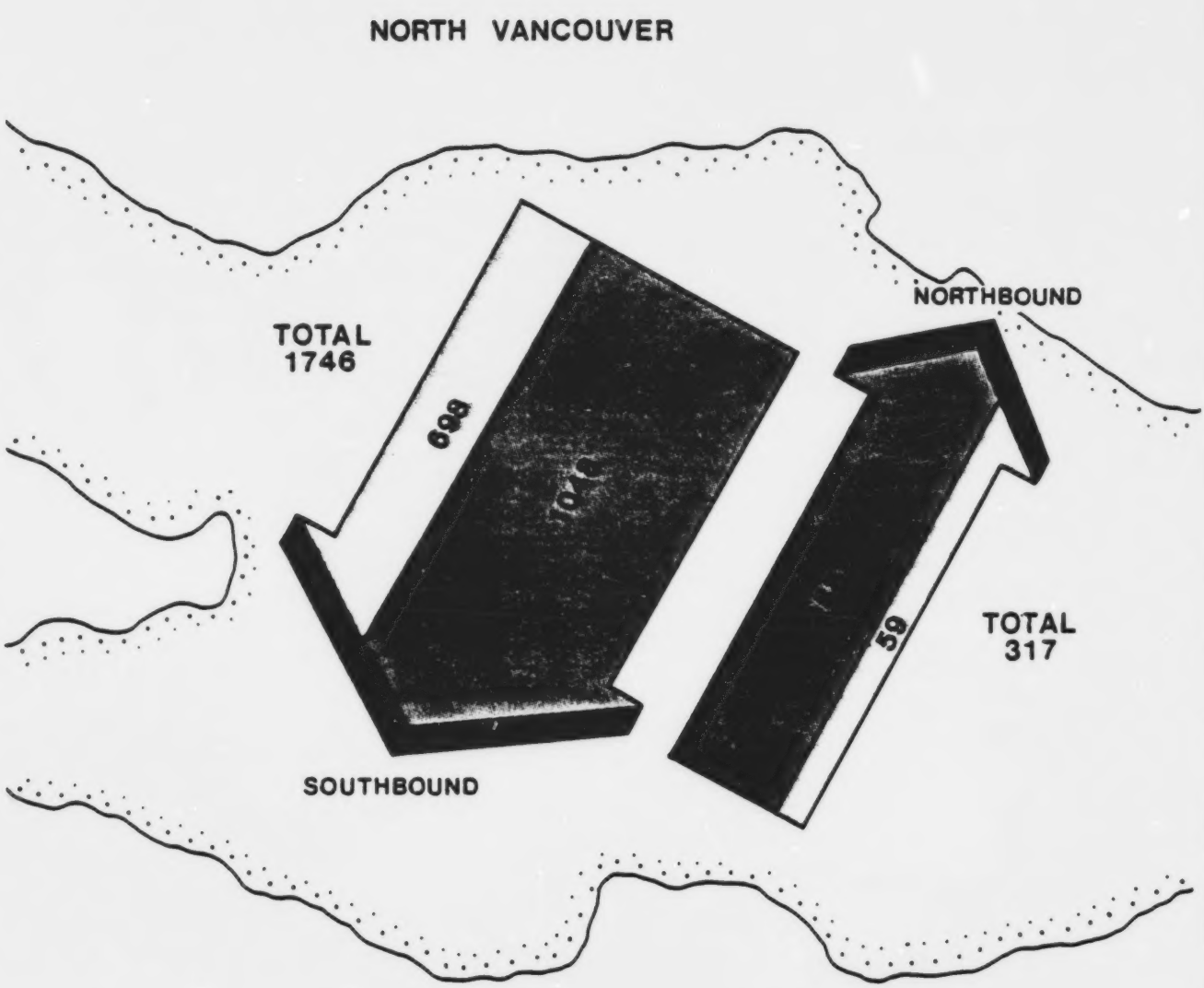


Figure 12

Peak Period Travel
(Wednesday, 7a.m. - 9a.m.)

Trip Purpose	Total Number of Passengers					
	Southbound		Northbound		Both Directions	
	No.	%	No.	%	No.	%
Work	753	(72.8)	142	(13.7)	895	(86.6)
Shopping	5	(0.5)	0	(0.0)	5	(0.4)
Personal Business	11	(1.1)	3	(0.3)	14	(1.4)
Social/Recreation	3	(0.3)	6	(0.5)	9	(0.8)
School or College	55	(5.3)	40	(3.9)	95	(9.2)
All Others	4	(0.4)	12	(1.2)	16	(1.6)
TOTAL					1,034*	(100.0%)

* Excludes non-response (Sample size = 1,421)

Table 8. Peak Period Trip Purpose by Direction (Wednesday, 7 am - 9 am)

Trip Purpose	Total Number of Passengers*			
	Southbound	Northbound	Both Directions	
Work	35	35	70	(7.9%)
Shopping	182	79	261	(29.6%)
Personal Business	12	7	19	(2.2%)
Social/Recreation	191	199	390	(44.3%)
School or College	12	3	15	(1.7%)
All Others	39	87	126	(14.3%)
TOTAL			881**	(100.0%)

* Excludes those in the 7-9 am period, but includes 7-9 pm period
** Excludes non-response (Sample size = 929)

Table 9 Trip Purpose for Saturday, by Direction

Service Area

The Sea-Bus draws a large proportion of its patrons from origins close to the terminals.

According to the Wednesday responses, 20.8% of the Sea-Bus passengers indicated an origin and destination in one of the geographical zones 1, 26, and 27. These zones are outlined in Figure 13. The majority of trip origins and destinations for the combined weekdays (55.2%) accounted for one of the zones 1, 2, 3, 24, 25, 26, 27 (refer to Figure 14). The percentage of the "commuter shed" shifts to 47.3% by including the origins and destinations in zones 4, 9, 23, and 28. Trip density is therefore greatest within relatively short distances from the Sea-Bus ferry terminals on both shorelines.

Origin/Destination Modes

The Sea-Bus passengers surveyed were asked to indicate their origin and destination modes. The results have been tabulated for the total survey period, for Wednesday, and for the Wednesday peak period.

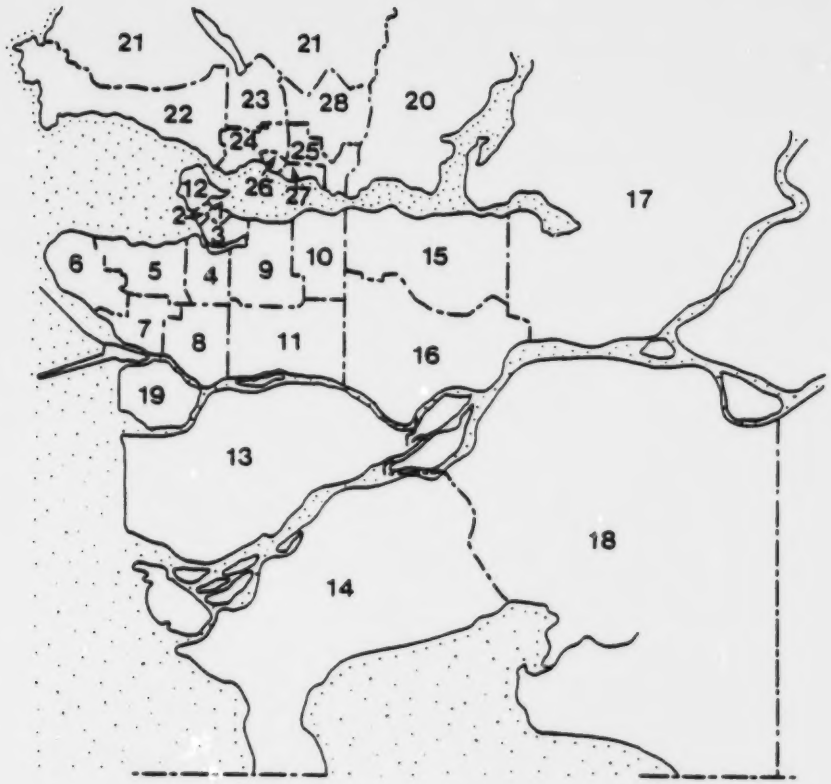
As shown in Table 10, bus and walk access and egress constitute the predominant modes of travel to or from the terminals on the weekdays. Buses account for approximately 53% of the access and about 50% of the egress modes. This high proportion of transit use is expected since Sea-Bus was initially planned as a link in the overall bus transit system.

The compact service area of the Sea-Bus "commuter shed" also encourages patrons to walk to and walk from the terminals (26% and 38.8% respectively). In Table 11 these percentages are about the same, or perhaps slightly greater, on a typical commuting day. Table 12 reveals that the percentages of walk trips to the Sea-Bus decreases during the a.m. peak period to about 17% for southbound travel and 11% for northbound.

On the other hand, the percentage by bus increases in the peak period. This may be explained by suggesting that when journey time is not a particular constraint, as perhaps in the afternoon peak period, Sea-Bus patrons walk to and from the terminals.

Table 13 shows how trips are linked between access and egress to and from the Sea-Bus during a typical commuting day. About 10% of the southbound passengers and approximately 6% of the northbound passengers walk both to and from the Sea-Bus.

Further, it appears that a substantial proportion of commuters use the bus service on the North Shore and walk within the CBD of Vancouver (37% southbound and 26% northbound). It is surprising, however, that over 30% of commuters to the CBD use the bus to get to



1	Vancouver Office District	15	North Burnaby
2	West End	16	South Burnaby
3	Vancouver Retail District	17	Ioco
4	Fairview	18	Surrey
5	Kitsilano	19	Sea Island
6	UBC	20	Deep Cove
7	Dunbar	21	Grouse Mountain
8	Shaughnessy	22	West Vancouver
9	East End	23	Capilano
10	Grandview	24	Upper West Lonsdale
11	South Vancouver	25	Upper East Lonsdale
12	Stanley Park	26	Central Lower Lonsdale
13	Richmond	27	Lower East Lonsdale
14	Delta	28	Lynn Valley

Figure 13

Origin Destination Zones

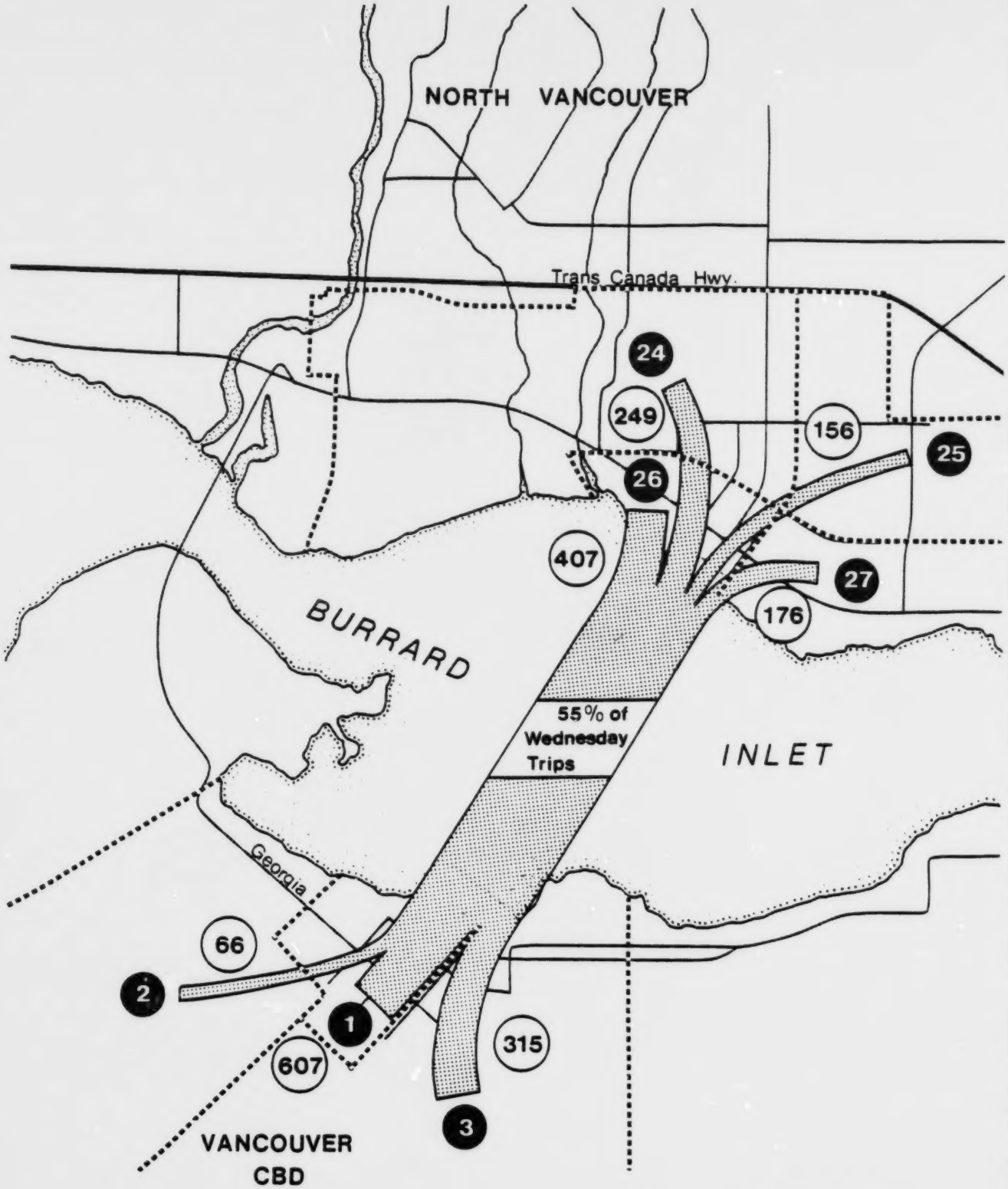


Figure 14

Sea · Bus

Major Service Areas

Access/Egress Mode	Access No. of Passengers	Access %	Egress No. of Passengers	Egress %
Walk	1,451	(26.6)	2,114	(38.8)
Car Driver	413	(7.6)	148	(2.7)
Car Passenger	353	(6.5)	154	(2.8)
Bus, no transfer	1,188	(21.8)	829	(15.2)
Bus, with transfer	1,686	(30.9)	1,899	(34.8)
Car and Bus	84	(1.5)	35	(0.6)
Taxi	39	(0.7)	30	(0.6)
Other	243	(4.4)	243	(4.5)
TOTAL	5,457*	(100.0)	5,452*	(100.0)

* Excludes non-response (Sample size = 5,513)

Table 10 Combined Access and Egress Mode to and from Sea-Bus (Wed. - Sat. inclusive)

Access/Egress Mode	Access No. of Passengers	Access %	Egress No. of Passengers	Egress %
Walk	526	(26.1)	878	(43.5)
Car Driver	115	(5.7)	39	(1.9)
Car Passenger	98	(4.9)	39	(1.9)
Bus, no transfer	532	(26.3)	336	(16.6)
Bus, with transfer	645	(31.9)	637	(31.5)
Car and Bus	32	(1.6)	10	(0.5)
Taxi	3	(0.1)	4	(0.2)
Other	68	(3.4)	77	(3.9)
TOTAL	2,019*	(100.0)	2,020*	(100.0)

* Excludes non-response

Table 11 Daily Access and Egress Mode to and from Sea-Bus Typical Commuter Day (Wednesday)

Access Mode	Southbound No. of Passengers	%	Northbound No. of Passengers	%	Both Directions No. of Passengers	%
Walk	138	(16.6)	22	(11.0)	160	(15.5)
Car Driver	33	(4.0)	6	(3.0)	39	(3.8)
Car Passenger	50	(6.0)	7	(3.5)	57	(5.5)
Bus, no transfer	285	(34.3)	52	(26.0)	337	(32.7)
Bus, with transfer	279	(33.6)	96	(48.0)	375	(36.4)
Car and Bus	14	(1.7)	4	(2.0)	18	(1.7)
Other	31	(3.7)	13	(6.5)	44	(4.4)
TOTAL					1,030*	(100.0%)

* Excludes non-responses

Table 12 Peak Period Access Mode to Sea-Bus by Direction (Wednesday, 7-9 am)

Access Mode	Egress Mode: Walk No. of Passengers	%	Bus** No. of Passengers	%	Total Sample
Southbound:					
Walk	99	(10.1)	69	(7.0)	
Car*	70	(7.1)	34	(3.5)	980
Bus**	310	(31.6)	296	(30.2)	
Northbound:					
Walk	35	(6.0)	150	(25.9)	
Car*	12	(2.1)	6	(1.0)	579
Bus**	100	(17.3)	183	(31.6)	

* Car Driver and Car Passenger
** Bus with and without a transfer

Table 13 Linked Trips for Major Access and Egress Modes Used on Typical Commuting Day (Wednesday, 7 am - 6 pm)

their final destination. This is no doubt due to the relatively large proportion of trips that go to Zone 3 as a destination (52.6%) in which the work opportunities are rather widely dispersed.

Travel Modes Before Sea-Bus

The survey asked those passengers who previously made the trip across the Inlet to indicate which mode they used. This information was to provide an indicator to measure Sea-Bus impacts on reducing automobile or bus traffic on the bridges.

On a typical commuting day (Wednesday) approximately 25% of the passengers had driven a car for the same trip prior to Sea-Bus. By including car passengers in this group, the proportion shifted to over 28%. Combination of the total weekday responses constituted 26% and on Saturday, 32%.

A significant number of passengers (40%) who drove across the Inlet now use their car to get to the Sea-Bus terminal. In all, only 14% of the patrons who possess a car leave it at home as a result of using Sea-Bus.

A larger proportion of the Wednesday patrons (61.1%) travelled by bus across the Inlet before Sea-Bus service was implemented. Based on the total sample population, 56.6% of the responses accounted for bus travel prior to Sea-Bus.

The results of the Wednesday sample indicated that 38% of the patrons did not make the same trip before Sea-Bus was inaugurated. Of this group there has been a 68% increase in the number of people who use the bus to access or egress the Sea-Bus terminals.

Personal Characteristics

The passenger survey results suggest that a smaller proportion of females, fewer young and aged and few captives use the Sea-Bus than transit in general (refer to Table 14). It also appears that the characteristics of all transit riders from the North Shore communities are themselves different from that of the region. This is consistent with the findings of a mode choice study done in 1971.

The mode choice study indicates that North Shore transit patrons in general having higher incomes, are more likely to have managerial occupations, have a higher automobile ownership rate and consist of more of the middle age group than is usual. With the exception of income, the Sea-Bus patrons also reflect the same characteristics. The median age is 33 years and the median annual income is $19,800. This income rate although lower than that of the region ($22,870), is consistent with the median for North Vancouver City ($20,398). The ferry patrons therefore reflect the market area served by Sea-Bus.

Study (Date)	% Female	Age % < 21	Age % > 65	% Captive*
Sea-Bus, 1983(1)	52	28[a]	3[b]	44
North Vancouver, 1967(2)	750	9[c]	4[d]	9[e]
Orilia, 1969(3)	71	39	19	25
Stratford, 1971(3)	77	31	14	85
Cornwall, 1969(3)	64	39	19	75
Kingston, 1971(3)	60	10	6	64
Guelph, 1969(3)	75			80
Thunder Bay, 1971(3)	65	43	5	60
Kitchner, 1976(3)	66	44	7	60
Windsor, 1976(3)	61	40	5	69
Toronto, 1964(3)				73
Vancouver, 1976(4)				63

Sources:

(1) Sea-Bus Wednesday Survey Results, March 23, 1983

(2) Immediate Improvements to Public Transportation in Greater Vancouver, G.V.R.D., 1971

(3) Canadian Transit Handbook, 1980

(4) 1976 Transit Survey, City of Vancouver Engineering, Sept. 1977

* Definition: No driver's licence, no car availability
a = < 24; b = > 64; c = < 20; d = > 60; e = transit users from households with no car

Table 14 Personal Characteristics of Canadian Transit Riders

Users' Evaluation

The users' impression of Sea-Bus service provides a useful tool to determine the level of service offered by Sea-Bus. The final question in the survey form asked passengers to mention any inconveniences or difficulties encountered with the Sea-Bus service and bus service.

The question was designed to elicit a wide range of responses. A total of 3,707 comments were given by the users. In many cases, several individual comments were given in response to the question. The responses were classified according to the most frequently mentioned comments.

The results of the questions are provided in Figures 15 to 20. In comparison to bus service, it seems that a large proportion of users are satisfied with the present level of service provided by Sea-Bus (refer to Figure 15).

Most of the transportation problems as illustrated in Figure 16, are associated with accessibility, operating schedule and frequency of Sea-Bus service. The most common complaint is the infrequent service provided on weekends and during the evening. This is when one ferry usually operates at 1/2 hour intervals. Many of the Sea-Bus users would also like extended service hours, particularly in the evenings. Further, much concern was expressed over the length of time it takes for each crossing. It is possible that the present crossing on dog legs influences peoples' perception of the crossing time.

It is interesting to note that some patrons suggested an expansion of the Sea-Bus concept to serve other areas in Vancouver.

Some of the North Shore and bus service routes were re-designed to coordinate with Sea-Bus service. According to the responses on the bus service, this has not been fully achieved. About 56.6% of the sample group would like to see better bus connections with Sea-Bus departure and arrival times.

A number of the facilities on-board the vessels which may require improvements are indicated in Figure 17. The high noise level on-board comprises the greatest deficiency with Sea-Bus facilities. Other than this, poor ventilation was identified as an additional inconvenience on-board.

A wide range of improvements were suggested for providing better service at the terminals. Most importantly, many passengers would like the ticket dispensers relocated to the area near the turnstiles.

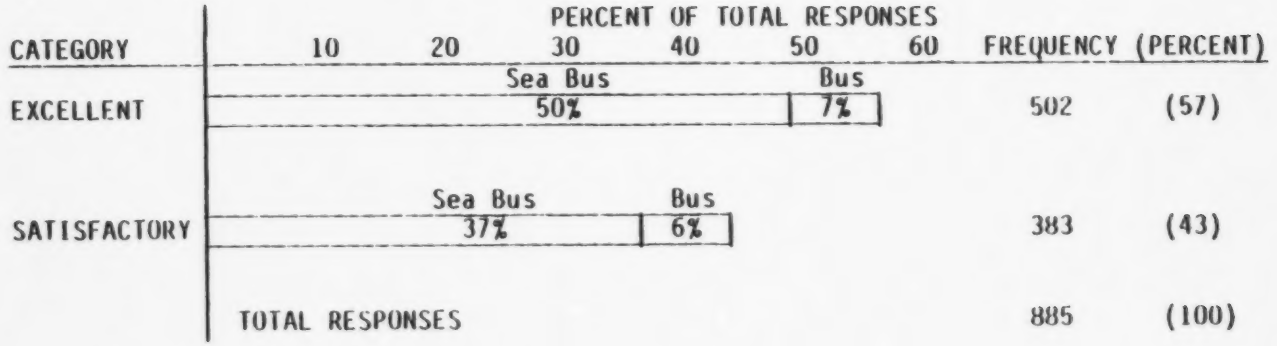


Figure 15

Service Evaluation

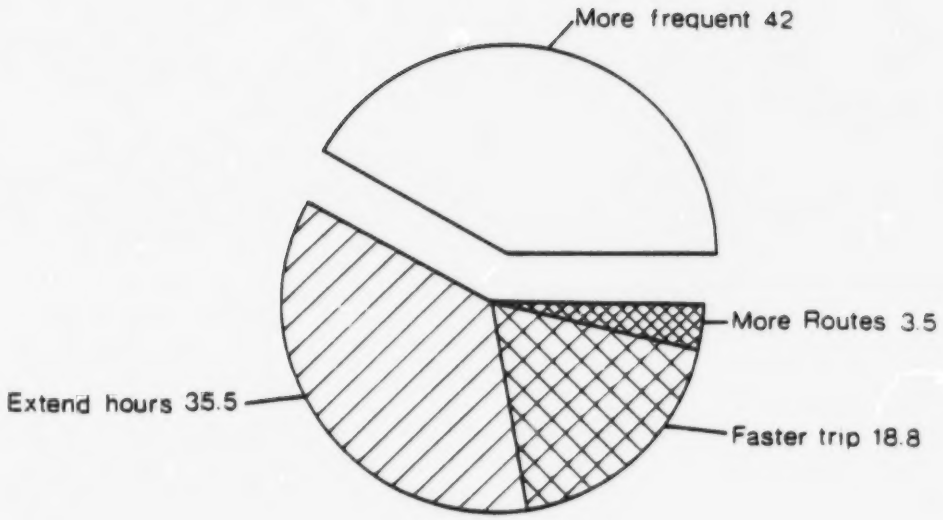


Figure16

Transport Service Improvements

CATEGORY	PERCENT 5 10 15 20 25 30 35	FREQUENCY	(PERCENT)
ON-BOARD:			
. REDUCE NOISE LEVEL	----------	133	(36)
. IMPROVE VENTILATION	-------	26	(7)
TERMINAL:			
. RELOCATE TICKET DISPENSERS	----------	47	(13)
. REDUCE WALKING DISTANCE (VANCOUVER TERMINAL)	----------	46	(12)
. FACILITATE WHEELCHAIR/ STROLLER ACCESS	----------	40	(11)
. IMPROVE HEATING SYSTEM	---------	32	(9)
. FACILITATE ENTRY/EXIT	------	23	(6)
. PREVENT OVERCROWDING IN DEPARTURE LOUNGE	------	23	(6)
	TOTAL RESPONSES	310	(100)

Figure 17

Facility Improvements

The comments made in reference to a variety of operations issues are outlined in Figure 18. Much dissatisfaction was expressed over the present restrictions on bicycle use. Most of the other complaints were directed toward the existing schedules and fares.

The categories listed in Figure 19 represent the most important amenities that passengers would like to have added to Sea-Bus. Individual responses that constitute "other" and "unclassified" account for a significant number of the responses. It is important to note that the suggested amenities are relatively subjective and are not representative of the entire sample group. It is likely that many passengers would oppose their addition.

Facilities that would require substantial modifications or additions to the Sea-Bus system are identified in Figure 20. Provision of park and ride was primarily requested by North Shore patrons. Concession facilities and change machines at both terminals were considered important features for improving user convenience. It was further suggested that the availability of an observation deck would appeal to the tourist element as well as make the trip more enjoyable for daily commuters.

2.2 Sea-Bus Impacts

The assessment of Sea-Bus impacts on transportation is based on the background information given in the previous section. The implications of the survey results are that the major impacts of Sea-Bus are subtle and perhaps more important in the long run. Within this category are the intangible benefits of the system to the people it serves even though alternative modes are available. Furthermore, new travel and other opportunities have arisen as a result of Sea-Bus. The traffic count data suggest that the impacts of Sea-Bus on trans-inlet traffic are less significant.

The following focuses on these transportation impacts of Sea- Bus for the three areas: Sea-Bus alternative, the trans-inlet transportation system, and traffic system changes.

2.2.1 Sea-Bus Alternative

Since its intiation Sea-Bus has provided a unique service unlike other public transit. The service has always been reliable and seating is assured at all times. The comfort experienced on the ride in addition to an uninterrupted journey with a harbour view, enhances the character of the service. As the passenger survey results suggest these attributes constitute a major travel impact of Sea-Bus.

Travel Time

One of the major impacts of Sea-Bus is that the service is an attractive transportation mode irrespective of time penalties incurred by

CATEGORY	PERCENT 10 20 30 40 50	FREQUENCY	(PERCENT)
. BICYCLE PROVISION ON-BOARD AT ALL TIMES	----------	79	(29)
. ANNOUNCE DEPARTURE TIMES MORE OFTEN	----------	63	(27)
. INCREASE TRANSFER INSPECTION	----------	37	(14)
. IMPROVE DEPARTURE TIME SCHEDULE	------	22	(8)
. PROVIDE TOKENS OR TICKETS	------	22	(8)
. REDUCE FARES	-----	20	(7)
. MAKE SCHEDULES AVAILABLE	-----	20	(7)
. OTHER	---	7	(13)
	TOTAL RESPONSES	270	(100)

Figure 18

Operation Improvements

CATEGORY	PERCENT 5 10 15 20 25	FREQUENCY	(PERCENT)
ON-BOARD: (SEA BUS)			
. MUSIC	----------	83	(25)
. PADDED SEATS	----------	41	(13)
. SMOKING SECTION	---------	22	(7)
. EVENING LIGHTING	--------	21	(6)
. OTHER	---------	22	(7)
TERMINAL: (SEA BUS)			
. SMOKING/NON-SMOKING SECTION	----------	44	(13)
. OTHER	--	5	(1)
UNCLASSIFIED	----------	89	(27)
	TOTAL RESPONSES	470	(100)

Figure 19

Amenity Services

CATEGORY	PERCENT 10 20 30 40	FREQUENCY	(PERCENT)
PARK & RIDE	----------	158	(38)
TERMINAL CONCESSIONS	----------	87	(21)
CHANGE MACHINES	----------	80	(19)
ON-BOARD WASHROOMS	---------	38	(9)
OBSERVATION DECK	-------	29	(7)
COVERED WALKWAY CONNECTING TO NORTH SHORE BUS TERMINAL	----	15	(4)
MORE SEATING IN TERMINALS	--	11	(2)
	TOTAL RESPONSES	418	(100)

Figure 20

Additional Facilities

the users. There is also a significant demand for Sea-Bus in spite of substantial walking and waiting as part of the entire trans-inlet trip.

The mean average travel time of 50 minutes to complete a trans-inlet trip with Sea-Bus as a link is substantially greater than transit travel in other parts of Greater Vancouver. As shown in Table 15 Sea-Bus travel time with access and egress modes is almost 1.5 times greater than for all transit trips in the region. This is further evident in the comparison of travel times for school and work purposes. In addition, transit travel from the North Shore communities to Downtown Vancouver takes about 34 minutes. Use of the automobile for the same trip requires 20 minutes. Thus, trans-inlet trips which include Sea-Bus require more time than travel by competing modes.

These comparisons suggest that travel time is not an important criterion in the passengers' decision to use Sea-Bus. Even the majority of patrons (63%) who switched to Sea-Bus now experience greater than or equal travel times for the same trans-inlet trip.

Some of the reasons for using Sea-Bus may be associated with the attraction of Sea-Bus for commuting which is related to its special character. Those people attracted to Sea-Bus are perhaps willing to forego travel travel time for this unique characteristic of Sea-Bus. Comparing work trip travel times via Sea-Bus modes (48.1 minutes) with the mid-range average for bus trips in the region (43.5 minutes) appears to indicate that there is an intangible benefit for Sea-Bus users which is approximately worth the additional travel times. These benefits can be seen as the quality of ride across the Inlet, reliable service schedule and assurance of a seat on Sea-Bus.

The attractiveness of Sea-Bus also tends to outweigh the negative values of walking and waiting times associated with a trans-inlet trip via Sea-Bus. The mean access time to the terminals, (25 minutes), in addition to the Sea-Bus crossing time of 12 minutes, constitute only a portion of the overall mean trip time of 50 minutes. Some of the remaining time includes walking, waiting, as well as a bus transfer for many patrons. This condition also is associated with egress times (17 minutes).

This acceptance of the travel times by Sea-Bus users seems to defy some of the conventional wisdom about walking. The Canadian Transit Handbook, 1980, quotes travel time studies of Toronto (1964) and Kitchener (1977). The access and egress walk times were 3 minutes and 2.3 minutes respectively in Toronto and 2.9 minutes in Kitchener. The handbook also states that few people will walk more than 600 metres. While the time and distance walked to access and egress a transit system will vary with city size and socioeconomic status, it appears that many of those who use Sea-Bus will walk farther than an average transit patron.

School and Work Trips	
Mode	Mean Travel Time (Minutes)
Sea-Bus With Other Modes	54.0
Core Transit*	26.2
Suburban Transit*	34.0
All Trip Purposes	
Sea-Bus	50.1
All Transit**	33.8
Bus (over 15 minutes)**	61.2
Bus (between 15 & 90 minutes)**	43.2

* Public Attitude, Awareness and Trip Behaviour Study Greater Vancouver Transit System, 1982

** Vancouver Area Transportation Study, (VATS), 1973

Table 15 Mean Travel Time by Transit in the Greater Vancouver Region

Sea-Bus, unlike transit bus service, caters to a substantial proportion of automobile drivers. Over half of the patrons reported having a car available for the trip. Taking this into account, it is highly probable that parking costs in downtown detours this group from using a car. The unique attributes of Sea-Bus may also encourage these patrons to use the facility as an alternative to the car.

New Opportunities

Since the introduction of Sea-Bus a number of travel opportunities has arisen which were previously not available. Sea-Bus has provided an additional tourism activity and, to some degree, has encouraged considerable usage for shopping purposes. The trip purpose results indicated social recreational (13%) and shopping (8.9%) as substantial proportions of Sea-Bus weekday trips.

It can be assumed that a proportion of the social recreational trips represent tourist travel. In this case, the Sea-Bus provides an inexpensive opportunity to obtain a panoramic glimpse of the Port of Vancouver and surroundings. This option was not previously available. A "sightsee" by Sea-Bus is advertised in many local tourism brochures.

The shopping as well as the social recreational trips have implications on retail and other commercial activity near the terminals. An interview program with 145 Sea-Bus passengers was administered during the survey period. To assess the impact of Sea-Bus on shopping, the North Shore (48%) and Vancouver (72%) shoppers were asked if Sea-Bus influenced their shopping patterns. Over half of the Vancouver sample (52%) agreed that the presence of Sea-Bus encouraged them to shop more often near the Downtown terminal.

North Shore shoppers were less influenced by the availability of Sea-Bus. Shopping more often near the North Shore terminal accounted for 41% of the responses.

In response to the interview question on leisure time, 53% of the passengers stated that they tend to pursue social, recreational and entertainment activities more often as a result of Sea-Bus.

The interview program represents only a small proportion of Sea-Bus travellers. The results, however, provide certain indicators which suggest that Sea-Bus is having some effect on promoting social, recreational and shopping activities. The trip across the Inlet with Sea-Bus is in itself an enjoyable recreational experience.

An additional impact of Sea-Bus is its apparent function of linking the CBD of Vancouver to North Vancouver. As the passenger survey indicated, on a typical commuting day about 10% of the southbound and approximately 6% of the northbound passengers walk both to and from the Sea-Bus. It can be argued that these people view Sea-Bus as an urban people mover expanding the CBD of Vancouver to include the node of residential development on the North Shore. In this context

Lower Lonsdale can be seen in a similar relation to the CBD of Vancouver as the West End. This has become possible with Sea-Bus providing the connecting link bringing the two areas within about 12 minutes of each other. Also, this represents a regional impact and meets one objective of the region which is to encourage residential development closer to the city centre.

2.2.2 Trans-Inlet Transportation System

The implementation of Sea-Bus was in part intended to provide an alternative mode which would help reduce the traffic using the bridge crossings. In some respects Sea-Bus has fulfilled this objective. It serves as a commuter route for a substantial share of the trans-inlet travel market. It has had a minimal impact on reducing automobile traffic on the bridges but some buses were removed from Lions Gate Bridge as a result of the service. The introduction of Sea-Bus also presented the opportunity to re-design and improve the North Shore bus system.

Traffic Volume

There has been no substantial changes in the traffic volumes on the Lions Gate and Second Narrows Bridges as a result of Sea-Bus. Traffic volume on the bridge crossings experienced a marginal increase in the early 1970's with a decline or stable state in the past three years. The economic recession may, in part, be attributable to this decline. Its effect on Sea-Bus ridership is less pronounced. Sea-Bus ridership has increased slightly at an annual growth rate of 0.5%.

The Sea-Bus market share of the daily trans-inlet traffic is about 5%. The service has had a greater impact on trans-inlet traffic during the peak period. In the morning and evening commuting hours Sea-Bus represents about 7% of the volume. Furthermore, the seasonal ridership patterns show an increasing number of passengers using the facility on a regular basis for most of the year. This reflects the heavy commuting function of Sea-Bus.

Modal Impact

The primary modal impact of Sea-Bus has been on bus service. Many of the Sea-Bus passengers used to take the bus across the Inlet before Sea-Bus was implemented. The modal impact of Sea-Bus on private automobiles is almost negligible.

In response to the survey question regarding previous Sea-Bus travel modes, about 25% of the Wednesday patrons had driven a car for the same trip before Sea-Bus. The Wednesday morning peak period turnstile counts totalled 2,063 with 1,746 of these in the southbound direction. This southbound figure, with a modal split of 25% by car and assuming a car occupancy rate of 1.35, implies a removal of 323 cars from the southbound traffic flow. This reduction accounts for

traffic on both bridges during a two hour peak period. In a one hour peak period Sea-Bus removes less than 70 vehicles from the Lions Gate Bridge and less than 100 vehicles from the Second Narrows Bridge. This amounts to about a 1% reduction of vehicle traffic on the two bridge crossings.

Furthermore, 40% of Sea-Bus patrons who previously drove all the way to downtown Vancouver, now use their cars to reach the ferry terminal. About 14% of sample leave their cars at home as a result of using Sea-Bus.

The impact of Sea-Bus on bus transit is more optimistic. Based on the Wednesday sample, 61.1% used a bus to reach their destination before Sea-Bus. This rate was slightly lower at 56.6% for the total survey sample including the Saturday results. These figures suggest that there has been a shift away from bus usage for downtown trips to greater usage of the Sea-Bus for the same trip purpose.

The implementation of Sea-Bus resulted in the elimination of seven transit buses southbound on the Lions Gate Bridge during the morning one hour peak (to be discussed in the following). This is a reduction of approximately 350 seats across the Inlet per hour. Sea-Bus adds 1,600 seats per hour across the Inlet giving a net increase of 1,250 seats. Sea-Bus, therefore, is capable of servicing a substantially greater number of passengers than that provided by the original bus service.

Traffic System Changes

The initiation of Sea-Bus resulted in traffic system changes to the trans-inlet and North Shore bus system, and local traffic improvements on the North Shore. Sea-Bus presented the opportunity to re-design the existing bus system on the North Shore. Some of the changes in the bus system are therefore attributable to Sea-Bus while others reflect improvements to the existing network.

Bus Route Network and Service Frequency

The introduction of Sea-Bus service had a fairly substantial impact on North Vancouver bus routes and service frequency. West Vancouver bus service was not affected. In Vancouver, the Sea-Bus service was initially coordinated with two shuttle buses, one of which was discontinued due to lack of patronage. Additional bus routes in Downtown were adjusted to improve transfer connections with Sea-Bus. No major changes affecting the cost of the operation were made.

The North Shore bus system in operation prior to the introduction of Sea-Bus service is illustrated in Figure 21. A similar drawing in Figure 22, shows the bus system subsequent to Sea-Bus implementation. Both of the Figures represent bus service frequency during one a.m. peak hour on various routes and in a southbound direction. The specific details which form the basis of the drawings including

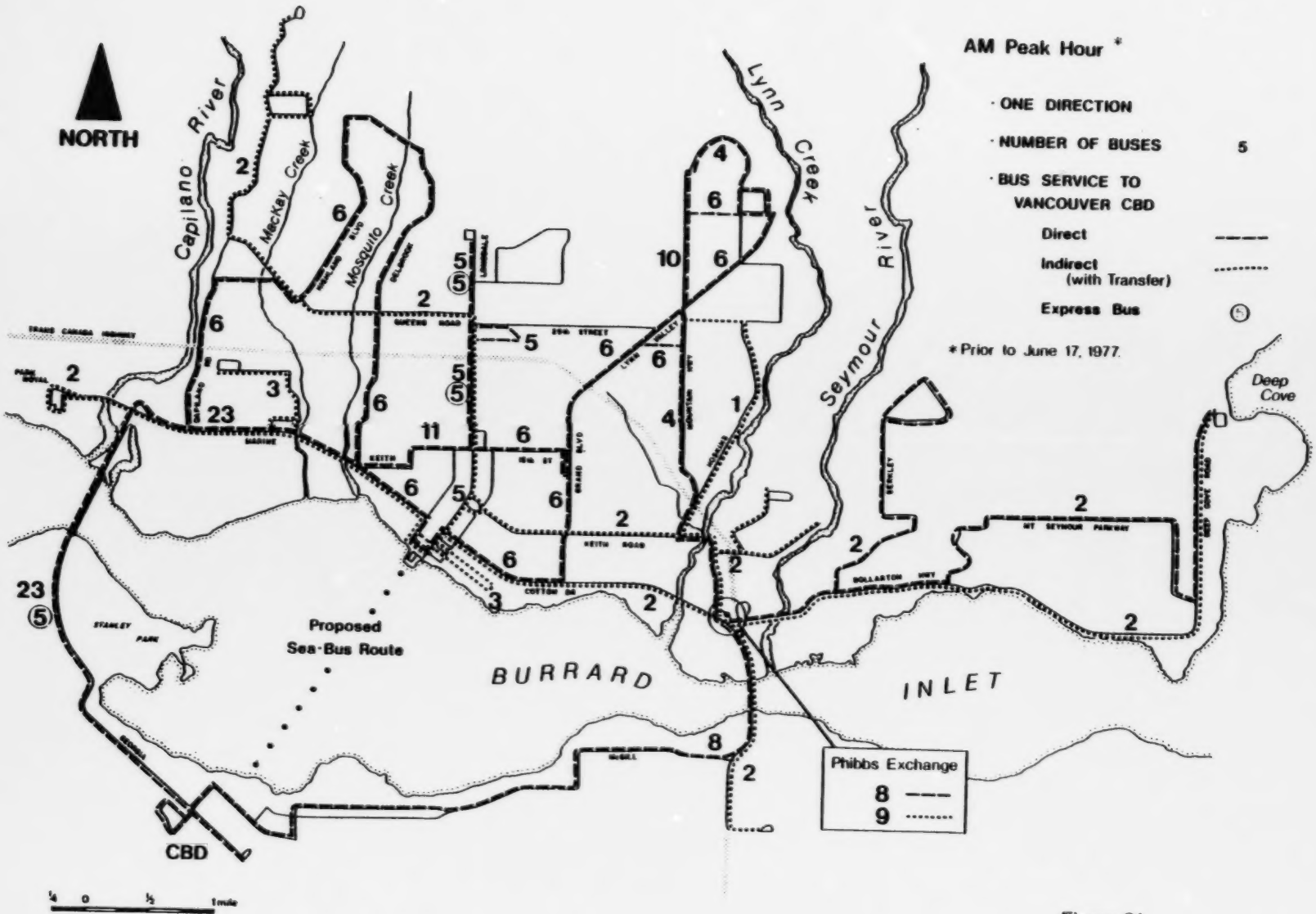


Figure 21

North Vancouver Bus Routes
Before Sea-Bus

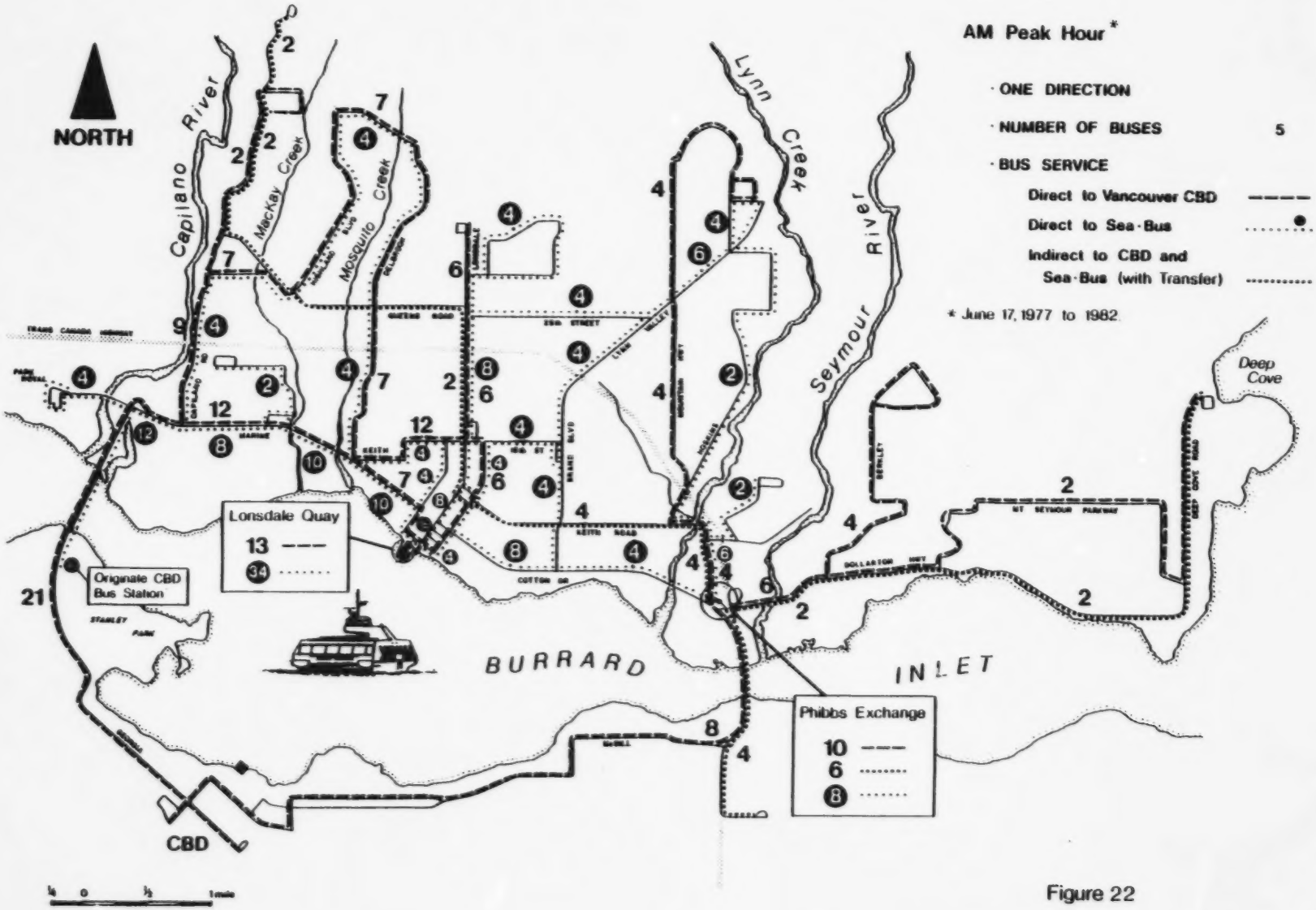


Figure 22

North Vancouver Bus Routes

After Sea-Bus

changes in bus numbers and routes as well as service frequency are outlined in Appendix D.

The general impact of Sea-Bus service was a removal of seven buses across the First Narrows Bridge. On a weekly basis, this amounted to 42 fewer bus trips, 13 of these were express trips (refer to Appendix D). The increased service on Second Narrows is not directly attributable to Sea-Bus but more a reflection of the improved North Shore/ Vancouver service.

A major impact of Sea-Bus was the cancellation of the 13 peak hour (7 a.m. - 9 a.m.) express trips from Upper Lonsdale to Downtown Vancouver via the First Narrows Bridge and an increase to 34 buses connecting directly to Sea-Bus. The former high speed service (18.5 km/h) was replaced with a lower speed (17 km/h) feeder service to Sea-Bus with fixed transfer time requirements. As a result, a more diverse network of bus/transfer options was introduced for greater access to Sea-Bus and slower service to Downtown Vancouver.

The increased number of feeder bus routes serving Sea-Bus included services from three outlying areas and three in-corridor routes.

Most of the new residential coverage was not directly related to the introduction of Sea-Bus although some portions were interconnected with the ferry service. The additional services were made possible by the equipment released through cancellation of services across the First Narrows Bridge.

An additional impact of Sea-Bus was on bus service hours and distances covered, as indicated in Table 16. The calculations shown are based on a standard work week, as defined by the Metro Transit Operating Company. The work week takes into account weekday, weekends, and holiday service. After Sea-Bus was introduced the total hours and kilometers of bus service increased. To determine the impact of Sea-Bus, it was necessary to deduct the hours and kilometers associated with the new bus system.

The results of the final calculations reveal that the implementation of Sea-Bus service affected bus service hours by the increase in the low speed feeder service provided to the terminal. The reduction in trans-inlet trips on the First Narrows resulted in a modest savings in kilometers operated on the North Shore. This was offset by the provision of new feeders for a net annual savings of about 7500 kilometers.

The substantial increases in bus hours are partially attributable to increased feeder bus service as well as to the expansion of the North Shore bus system.

The increase bus service, along with implementing Sea-Bus reflects the transit policy plan initiated at that time. The plan attempted to complement the Sea-Bus while retaining much of the Lions Gate bus

Standard Weekly Service		Hours	Kilometers
North Vancouver			
Prior to Sea-Bus		4,913	90,900
After Sea-Bus		5,306	92,300
Less new services			
#229 Westlynn	(47 hours)		
#230 Braemar Loop	(40 hours)		
#232 Queens/Misc.	(50 hours)		
TOTAL	(137 hours)	137	2,400
Revised service after Sea-Bus		5,169	89,900
Net weekly savings (increase) due to Sea-Bus		(256)	1,000
Vancouver			
Sea-Bus Granville Route		(93)	(850)
After Sea-Bus			
TOTAL WEEKLY SAVINGS (INCREASE) After Sea-Bus		(349)	150
ANNUAL SAVINGS (INCREASE) After Sea-Bus		(18,150)*	7,500**

* Increase in bus hours
** Decrease in distance

Table 16 Bus Service Hours and Kilometers

service. This has resulted in a high degree of route duplication and overlap, and increases in operating costs.

Local Traffic and Road Improvements

Prior to the implementation of Sea-Bus service a considerable amount of street and traffic improvements occurred in North Vancouver. Most of the changes were in direct response to local traffic and development needs and only indirectly related to Sea-Bus.

The major impact of Sea-Bus involved street construction to accommodate the original bus loop and a new one being located underneath the ICBC building. There were a few changes in local traffic devices to facilitate bus movement and pedestrian flow.

There has been no provision for park and ride facilities beyond a "kiss and ride" zone. The results of the passenger survey indicate that 40% of the Sea-Bus passengers who previously drove all the way to Downtown Vancouver now use their cars to get to Sea-Bus. This has the potential for increasing street congestion and parking near the terminal. It is already evident that many Sea-Bus passengers park their cars along streets and on vacant lots near the terminal. Once these lots are developed for other purposes on-street parking problems will probably become worse.

2.3 Conclusion

Sea-Bus was implemented to help relieve congestion by cars and buses on the routes between the North Shore and the CBD of Vancouver. In respect to buses particularly, it has achieved this objective. The major travel impact of the Sea-Bus, as interpreted from the findings of the on-board passenger survey are more the subtle benefits of the system.

The Sea-Bus operation has always maintained regular and reliable service. Since only 400 passengers are permitted on each vessel, seating is assured at all times. With the spacious interior, there is plenty of room to move about and view various parts of the harbour and city settings. These characteristics, unusual for a public transit system, enhances the quality of service. This has encouraged many people to use Sea-Bus rather than the competing modes, despite the travel time penalties incurred. An additional incentive for using Sea-Bus, particularly by commuters, may be a desire to avoid parking costs in Downtown Vancouver. Traffic congestion and socio-economic factors must also be considered as possible influences.

The Sea-Bus has become a commuting facility providing a useful third crossing of Burrard Inlet. It primarily serves people who live on the North Shore and work in Downtown Vancouver. The personal characteristics of Sea-Bus passengers reflect those of typical North Shore transit users.

An additional impact of Sea-Bus is its apparent function of linking the CBD of Vancouver with North Vancouver. The Lower Lonsdale area of North Vancouver, it is strongly suspected, is developing in a way which allows Sea-Bus to provide close links for residents who live there and work in downtown Vancouver. This is a regional impact and meets one objective of the region which is to encourage residential development close to the city centre. Sea-Bus appears to be doing this to some extent.

The introduction of Sea-Bus provided the impetus for rationalization and expansion of the North Vancouver transit service. It has had little impact on reducing trans-inlet automobile traffic, but has allowed a reduction in the number of buses across Lions Gate Bridge in the rush hour.

Although Sea-Bus has not made a substantial contribution to reducing traffic on the bridges, it has added a special dimension to the bus system. Sea-Bus, unlike bus service, is a unique transportation mode for the Vancouver region. The people who use it tend to be very satisfied with the level of service it offers.

3.0 ECONOMICS

This part of the study provides an evaluation of the economic impacts of Sea-Bus on the transportation system and some indirect economic aspects of Sea-Bus. The transportation system encompasses the trans-inlet travel modes of Sea-Bus and bus transit. Although the automobile is part of the transportation system there has been no discernible effect of Sea-Bus on its operations and other associated costs. Automobile traffic volume on the two bridge crossings has not changed significantly since the introduction of Sea-Bus service.

The economic impacts of Sea-Bus are determined in terms of its efficiency as a component of the public transit system. For this purpose the costs of Sea-Bus and bus transit have been analyzed and have been stated in terms of the residual cost or efficiency of the Sea-Bus system.

The effects of Sea-Bus on indirect economic aspects involves analysis of energy consumption and employment.

3.1 Transportation System

The assessment of Sea-Bus is based on the incremental costs of installing and operating Sea-Bus in lieu of services otherwise provided by regular bus. The costs of the bus system include those associated with changes made to the trans-inlet and North Shore services following the implementation of Sea-Bus.

The transportation system is also analyzed for the extreme assumptions that all the Sea-Bus passengers use bus transit or the automobile for the same trips.

3.1.1 Sea-Bus Costs

The cost of the Sea-Bus system includes the initial capital investment costs for the terminals and vessels and the installation of the North Shore bus loop and operations and maintenance costs. Sea-Bus annual costs and revenues are outlined in Tables 17 to 20.

The initial capital investment of Sea-Bus totalled $35.8 million. The annual cost of the investment has been estimated for the years 1980 to 1983 in the Tables. These calculations are based on a range of interest rates from 5% to 20% and an amortization period of 25 years.

The average residual cost (annual cost balance) of the various interest rates is indicated in Figure 23. With these different rates the annual capital investment costs contribute from 40% (at 5% interest) to 66% (at 20% interest) of the residual cost. The total residual cost for Sea-Bus therefore varies with the interest rate, but this does not change the direction of residual cost, only its

SEA-BUS ANNUAL COST ($ in Millions)						
Year	Amortized Capital (5%)	Operations & Maintenance	Revenue	Balance	Cost Increase of Bus Operations	Residual Cost
1980	2.540	3.707	0.720	5.527	0.346	5.873
1981	2.540	4.065	0.707	5.898	0.398	6.296
1982	2.540	4.443	0.748	6.235	0.458	6.693
1983	2.540	3.970	0.725	5.785	0.527	6.312
Avg	2.540	4.046	0.725	5.861	0.432	6.294
Total Annual Ridership			3,000,000			
Residual Cost Per Passenger			$2.098			

Table 17 Annual Costs and Residual Cost of Sea-Bus Operations

SEA-BUS ANNUAL COST ($ in Millions)						
Year	Amortized Capital (10%)	Operations & Maintenance	Revenue	Balance	Cost Increase of Bus Operations	Residual Cost
1980	3.944	3.707	0.720	6.931	0.346	7.277
1981	3.944	4.065	0.707	7.302	0.398	7.700
1982	3.944	4.443	0.748	7.639	0.458	8.097
1983	3.944	3.970	0.725	7.189	0.527	7.716
Avg	3.944	4.046	0.725	7.265	0.432	7.698
Total Annual Ridership			3,000,000			
Residual Cost Per Passenger			$2.566			

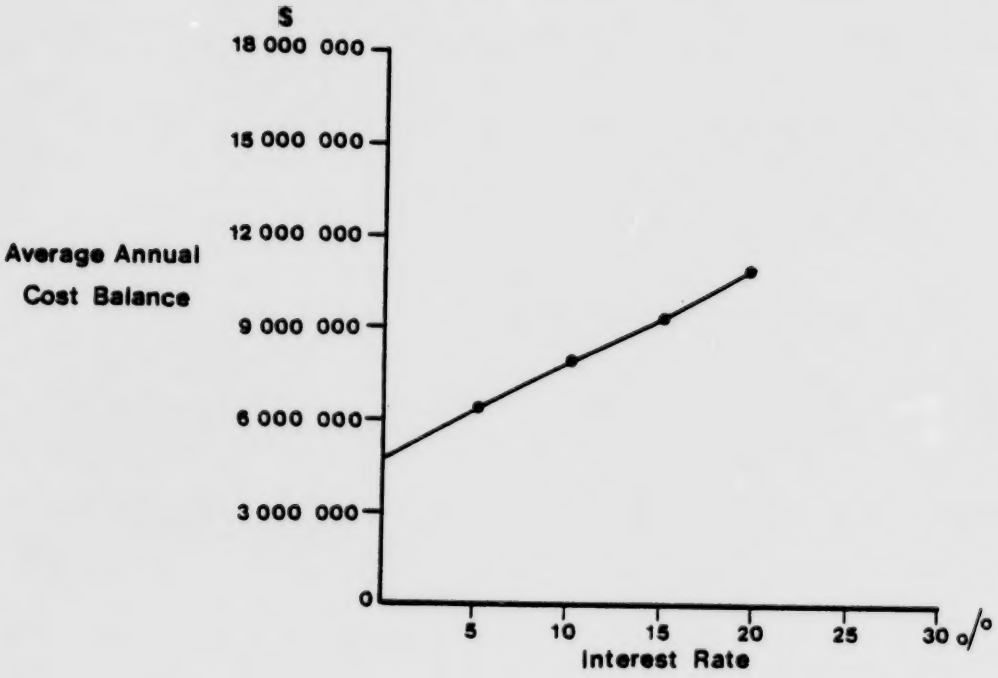
Table 18 Annual Costs and Residual Cost of Sea-Bus Operations

SEA-BUS ANNUAL COST ($ in Millions)						
Year	Amortized Capital (15%)	Operations & Maintenance	Revenue	Balance	Cost Increase of Bus Operations	Residual Cost
1980	5.538	3.707	0.720	8.525	0.346	8.871
1981	5.538	4.065	0.707	8.896	0.398	9.294
1982	5.538	4.443	0.748	9.233	0.458	9.691
1983	5.538	3.970	0.725	8.783	0.527	9.310
Avg	5.538	4.046	0.725	8.859	0.432	9.292
Total Annual Ridership			3,000,000			
Residual Cost Per Passenger			$3.097			

Table 19 Annual Costs and Residual Cost of Sea-Bus Operations

SEA-BUS ANNUAL COST ($ in Millions)						
Year	Amortized Capital (20%)	Operations & Maintenance	Revenue	Balance	Cost Increase of Bus Operations	Residual Cost
1980	7.236	3.707	0.720	10.223	0.346	10.569
1981	7.236	4.065	0.707	10.594	0.398	10.992
1982	7.236	4.443	0.748	10.931	0.458	10.389
1983	7.236	3.970	0.725	10.481	0.527	11.008
Avg	7.236	4.046	0.725	10.557	0.432	10.989
Total Annual Ridership			3,000,000			
Residual Cost Per Passenger			$3.663			

Table 20 Annual Costs and Residual Cost of Sea-Bus Operations



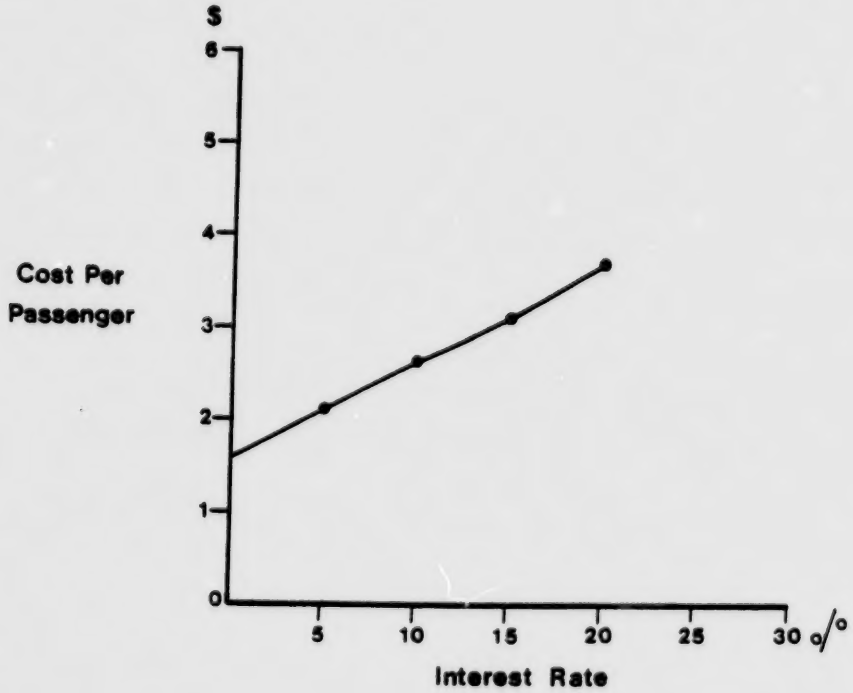


Figure 23
Sea-Bus
Residual Cost

magnitude. Even at a 0% interest rate the Sea-Bus residual cost would remain relatively high.

The operation and maintenance costs of the Sea-Bus system are based on year-end fiscal periods from March 31, 1980 to 1983. These costs account for employment, maintenance, administration, etc. and exclude capital costs. The annual revenue indicated in the Tables only includes revenue contributed directly to the Sea-Bus operation. Other revenue collected through the bus system by transfers or fare-cards for use of the Sea-Bus is classified as regular transit revenue.

3.1.2 Bus Transit Costs

The cost of transit bus operations on the two bridge crossings following the implementation of Sea-Bus has been measured to determine the efficiency of Sea-Bus.

The initial changes in the cost of the transit service reflect the 18,150 hours of increased North Shore service and a 7,500 kilometer reduction of trans-inlet service. Tables 17 to 20 show the increases in the cost of North Shore bus service in the past few years. These costs do not account for a capital cost saving of about 10%. They are based on 1982 costs of a driver at $25.50 per hour and operations at $0.70 per kilometer. The 1982 cost has been discounted back to 1980 at an average annual inflation rate of 15%.

3.1.3 Residual Costs

The net effect of Sea-Bus, taking into acount the changes in the bus transit service and vehicular traffic across the Inlet (no change), is a residual cost of about $6.3 million to $11.0 million, depending on the interest rate used. The residual cost summary is given in Table 21 and shown in Figure 23.

Interest Rate	Annual Residual Cost Total ($ mill.)	Per pass. ($)
5%	6,290,000	2.10
10%	7,700,000	2.57
15%	9,290,000	3.10
20%	10,990,000	3.66

Table 21 Residual Cost Summary

The magnitude of the residual cost with each interest rate implies that the Sea-Bus has not contributed directly to the economic efficiency of the trans-inlet transportation system.

3.1.4 Bus and Automobile Use Without Sea-Bus

The efficiency of the Sea-Bus system in this analysis is based on extreme alternatives to the operation of Sea-Bus.

If the number of passengers carried by Sea-Bus were to be accommodated by the bus system a total of 24 buses in the southbound two hour am peak and 27 buses in the northbound two hour pm peak periods would be required. This additional load would affect Lions Gate Bridge only. There has been no significant changes in the bus numbers on Second Narrows as a result of Sea-Bus. By assigning the increase to Lions Gate Bridge and considering the peak hour equal to 60% of the peak period, a maximum of 14 bus trips would have to be added during the am peak hour. In the one hour pm peak 16 bus trips would be required. This number represents the worst possible situation and does not include any spare capacity of the buses during the peak hour.

The addition of 14 buses of the Lions Gate Bridge would represent an increase of seven buses in the am peak hour over the number that was running prior to Sea-Bus. Therefore, to provide the equivalent Sea-Bus service these extra buses would have to be acquired.

The "turnaround" time of one bus trip across Lions Gate Bridge is about one hour. Therefore, seven buses in the am peak and nine in the pm peak would be required in addition to the number used prior to Sea-Bus. At the 1983 price of $170,000 per bus, the capital investment for acquiring these buses is $1.53 million.

The increase in bus traffic represents the equivalent space on the bridge of 20 - 30 cars in the peak hours. This would probably not have any discernable effect on traffic volume across the Lions Gate Bridge.

The provision of bus service in replacement of Sea-Bus would have a negligible effect on operations and maintenance costs. The maintenance and operating costs of Sea-Bus would be eliminated while bus costs would increase with the addition of drivers to operate them.

If all Sea-Bus passengers switched to private automobile use for the same trip there would be a significant increase in traffic on Lions Gate Bridge. The total number of cars would increase by 1050 in the morning and afternoon two hour peak periods with 420 of them in the am peak period. Considering the peak hour at 60% of the peak period, 250 extra cars would be added to southbound traffic in the one hour am peak.

The Lions Gate Bridge is presently operating at capacity during the am and pm peak hour. Any additional demand, such as 250 cars would probably extend the peak duration of capacity operation. The delay time at the north approach ramps would undoubtedly increase.

3.2 Indirect Transportation Aspects

In this category the effects of Sea-Bus on energy consumption and employment are outlined.

3.2.1 Energy Consumption

Energy consumption for the Sea-Bus has been categorized as direct energy or fuel, and indirect energy required for maintenance and associated facilities. A summary of energy consumption by the Sea-Bus system is indicated in Table 23.

The direct energy required for bus transit since the implementation of Sea-Bus has been reduced marginally. As previously indicated, the total travel saving of buses after Sea-Bus is about 7500 kilometers annually. Bus transit consumes about 50 litres of diesel fuel per 100 kilometers which amounts to a saving of 3750 litres of diesel per year.

The Sea-Bus operation requires a total of 1.26 million litres of diesel fuel per year. Based on a total of 137,000 kilometer travel per year by the two Sea-Buses, the unit consumption rate is about 9.2 litres per kilometer or 920 litres per 100 kilometers. It appears that the Sea-Bus operation consumes about 1.25 million more litres of diesel fuel a year than required for bus transit service across the Inlet.

To provide an equivalent bus service less diesel fuel would be required than that presently consumed by Sea-Bus. Based on an average travel distance of 10 kilometers by the additional buses, and 50 litres of fuel per 100 km, the daily fuel consumption of the increased bus service would be about 115 litres. This figure represents the bus trips required in the one hour peak period. The annual fuel consumption of the additional bus service is about 30,000 litres thus, Sea-Bus consumes about 41 times more fuel than an equivalent bus service.

In the event that all Sea-Bus passengers use the automobile, the daily traffic on the two bridge crossings would increase by a total of 5,400 vehicles. The energy consumption for these vehiclar trips depends on the car size and travel distance. The following assumptions have been made to calculate automobile energy consumption:

- Vehicles travel on an average 4% grade and 10 degree curve.
- The average distance from North Vancouver to Downtown Vancouver via Lions Gate Bridge is 10 kilometers.
- The average distance from North Vancouver to Downtown Vancouver via Second Narrows Bridge is 13 kilometers.
- The average automobile travel speed is 40 kilometers per hour.

The average distance is calculated from the Upper Levels Highway at Lonsdale in North Vancouver to Granville and Georgia Streets in Downtown Vancouver. It is also assumed that 60% of the daily vehicles would travel on Second Narrows Bridge and 40% would use the Lions Gate Bridge.

Table 22 indicates the energy consumed each day by private vehicles.

	Lions Gate Bridge	Second Narrows Bridge	Total
Number of Vehicles	2,160	3,240	5,400
Travel Distance (km)	10	13	
Total Travel Distance (km)	21,600	42,120	63,720
Fuel Consumption* (litres per km)	0.193	0.193	
Total Fuel Consumption (L)	4,170	8,130	12,300

* Institute of Transportation Engineers Handbook, 1982

Table 22 Daily Energy Consumption of Private Automobiles

Conversion of the daily fuel consumption to an annual consumption rate is based on a total of 260 work days per year. The annual energy consumption of private vehicles would total 94,400 GJ (3.2 million litres of gasoline). This is about 2.5 times the amount of Sea-Bus fuel consumption. It therefore appears that Sea-Bus saves a substantial amount of energy compared to that consumed by private vehicles for an equivalent service.

The indirect energy costs of Sea-Bus include the terminal and administration facilities and the bus transit loop on the North Shore. The total energy consumption is equivalent to about $85,800 per year. This cost is considered an additional cost to the bus system, which otherwise would not be required.

	Bus Transit Energy Saving Since Sea-Bus	Sea-Bus Consumption Per Year	Net Reduction or (Increase)
Direct Energy (Diesel)	3,750 L	1,260,000 L	(1,256,000 L)
Indirect Energy	Marginal Saving, assumed nil	$85,800	85,800

Table 23 Energy Consumption Summary

3.2.2 Employment

Another indirect transportation impact is the employment generated by the Sea-Bus operation. The employment impact has three components: initial employment during construction; the employment level as a result of Sea-Bus operation; and the change in employment in the bus system as a result of Sea-Bus operation.

The employment during the construction of the Sea-Bus included the vessel building and terminal facility construction. The total investment of the vessel and the terminal facilities amounted to $35.8 million in 1977. This amount included material and labour costs. The net effect on employment is difficult to assess given the number of people involved in manufacturing materials and equipment outside the immediate areas of Sea-Bus. The initial employment effect, therefore, was not considered in this analysis other than by the initial capital investment of $35.8 million.

The employment created by the Sea-Bus operation is given in Table 24. As a result of the Sea-Bus operation, the bus service has been increased by 18,150 hours of driver time per year.

	Annual Employment	
Sea-Bus	Persons	Cost ($ mill.)
On-board crew	9	.264
Operation	51	1.584
Engineers	15	0.528
TOTAL	75	2.376
Bus Operation Increase	10**	0.463
NET EMPLOYMENT GAIN	85	2.839

* 1982 Dollars
** Based on 18,150 hours

Table 24 Employment of the Sea-Bus Operation

About 27% of the annual residual cost as shown previously contributes to employment costs. These costs, spent as disposable income and assuming that everything else is equal, would have a positive effect on the Greater Vancouver economy. This effect and the multiplying effects are difficult to trace without any detailed analysis.

3.3 Conclusion

It can be concluded that the effects of Sea-Bus on the cost of the trans-inlet transportation system places the ferry service at an economic disadvantage. In comparison to an equivalent bus service, Sea-Bus incurs a higher cost and requires more energy for the operation. The quality of service delivered by Sea-Bus, however, is superior to that delivered by bus service. The employment generated by Sea-Bus has had a positive effect on the Greater Vancouver economy.

The Sea-Bus system is a long term investment. The terminals can accommodate up to eight vessels in the future without any expansion. Additional staff would not be required if more ferries were put into operation.

4.0 URBAN DEVELOPMENT

This part of the analysis focuses on the possible influences of Sea-Bus in shaping the urban fabric and form of the areas in the vicinity of the terminal sites. Based on initial investigations, it was found that Sea-Bus has had little impact on urban development in the vicinity of the South Shore terminal other than site acquisition. The analysis has therefore been directed toward impacts around the North Shore terminal site, in particular, the Lower Lonsdale area (refer to Figure 24).

4.1 Urban Growth Trends

This section presents a overview of urban development growth trends of the North Shore within a regional context. This is followed by an examination of recent development trends in Lower Lonsdale subsequent to the land assembly program initiated by the Province in 1974.

4.1.1 Regional Context

In a regional context the North Shore has absorbed a relatively small portion of urban development in the Greater Vancouver Regional District (GVRD). Based on estimates the Greater Vancouver's developed urban area expanded by 18,000 hectares between 1961 and 1981 while the North Shore only received 10% of this growth. As illustrated in Figure 25, most urban development in the GVRD has taken place south of the Fraser River. With respect to future expansion, Table 25 provides an indication of the potential growth designated in various areas.

Location	Industrial	Urban
South of Fraser River	74%	63%
North East Sector	11%	17%
Burrard Peninsula	14%	6%
North Shore	1%	14%

Table 25 Distribution of Land Designated for Metropolitan Expansion, 1981

The projections indicate that in general, the North Shore will continue to represent a fraction of new urban development in a regional context due to the availability of less expensive sites and good transportation facilities elsewhere.

4.1.2 Revitalization of Lower Lonsdale

As mentioned earlier in the report, Lower Lonsdale experienced limited growth following the closure of the ferry wharf in 1958. Subsequent municipal planning efforts involved a revitalization scheme in order to stimulate growth in the area. Initiation of the

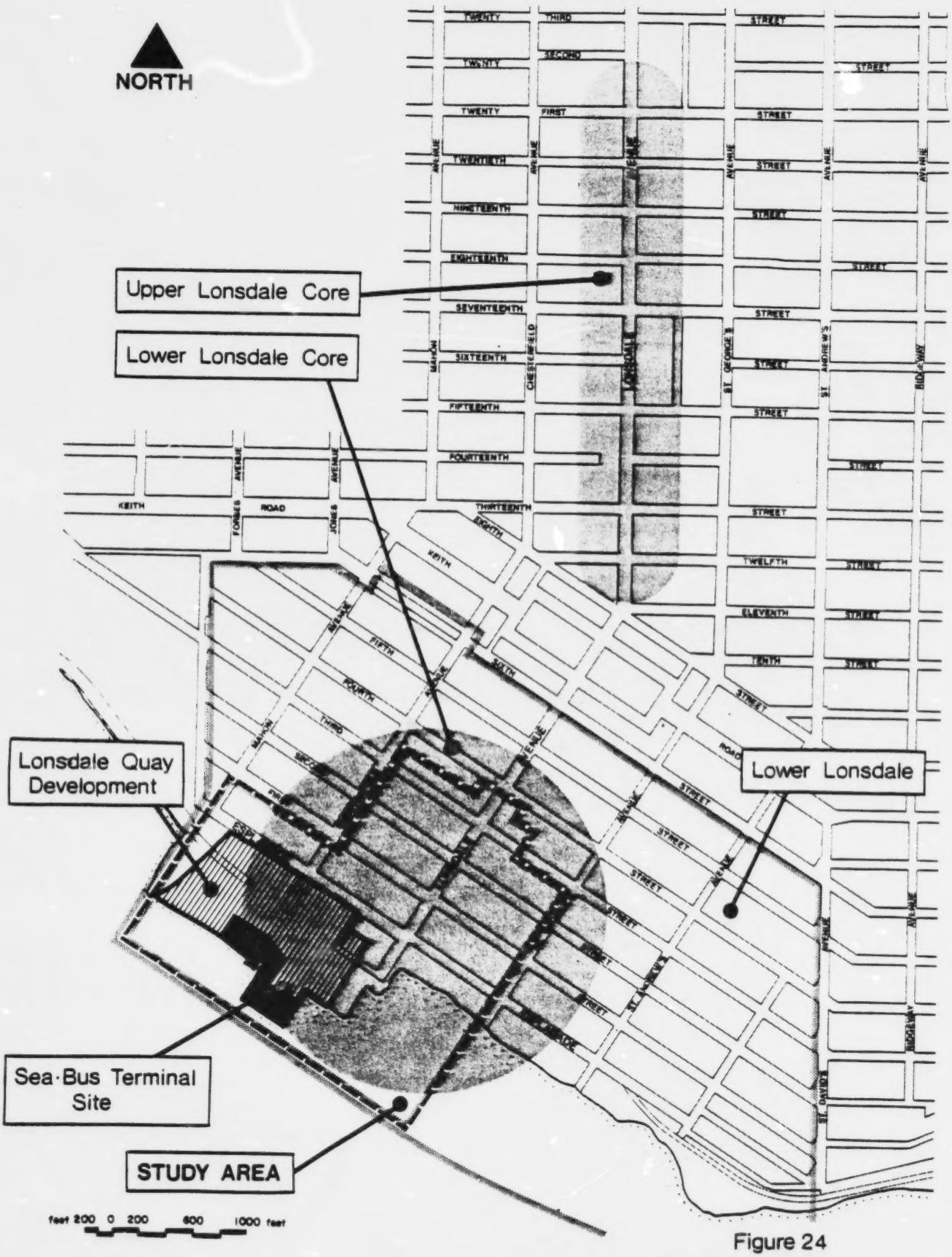
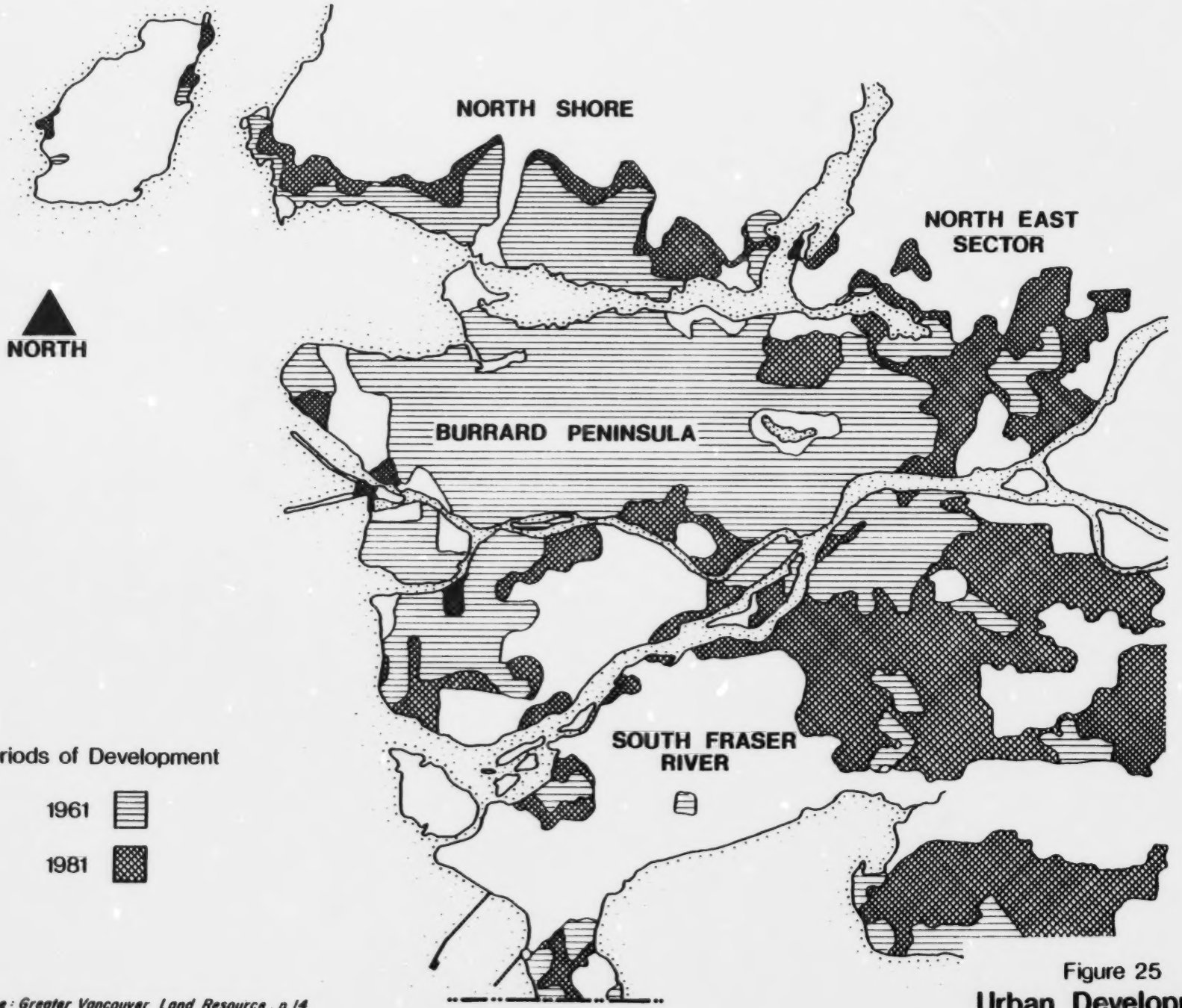


Figure 24

North Shore Study Areas



Source : Greater Vancouver Land Resource , p.14

Figure 25
Urban Development

Provincial land assembly program in 1974 and subsequent development of Lonsdale Quay largely contributed to this revitalization process.

In addition to new commercial buildings on Lonsdale Quay other recent developments in Lower Lonsdale include the low rise (2-3 storey) Esplanade and Waterfront Centres. These facilities border on Esplanade Street immediately north of Lonsdale Quay.

It appears that the province has taken the initiative for stimulating growth in the private sector by relocating the ICBC and BCR buildings to act as anchors to the Lonsdale Quay Project. This in turn has expedited development in the various parts of Lower Lonsdale.

4.2 Local Development Policies

The City of North Vancouver's Official Community Plan (May 1980) is one of a series of documents representative of the municipalities community planning program which began in 1971. In this section the Plan is discussed in conjunction with the "Zoning By-Law 1967" as amended, to find out if there were any linkages between the introduction of Sea-Bus and policies affecting development in the Lower Lonsdale area.

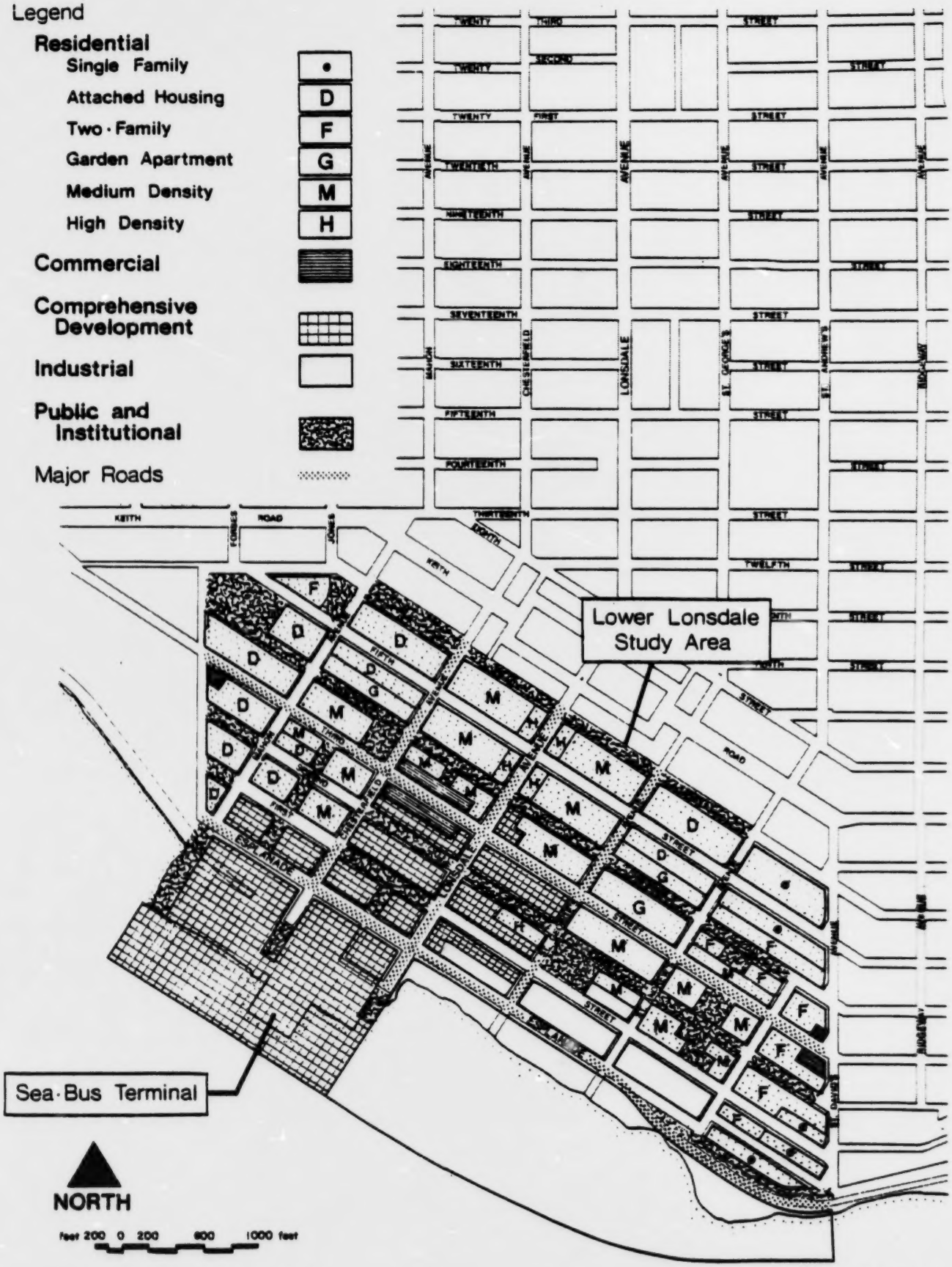
4.2.1 Official Community Plan

The 1974 provincial land assembly program combined with the proposal for a major transportation centre necessitated a number of changes to the existing planning policies at the time. The scale of the proposed development was much larger than what had earlier been advocated in planning policies. As a result, the Plan was amended to provide for increased land use densities in keeping with the concept (refer to Figure 26).

In recognition of the limited potential for new North Shore development, the Plan concentrates development within the context of an ultimate population of 50,000. Although several planning objectives encourage the retention of Upper Lonsdale as the main centre for commercial, community and institutional uses, equally as important is the redevelopment of Lower Lonsdale as a centre focal point for the North Shore waterfront.

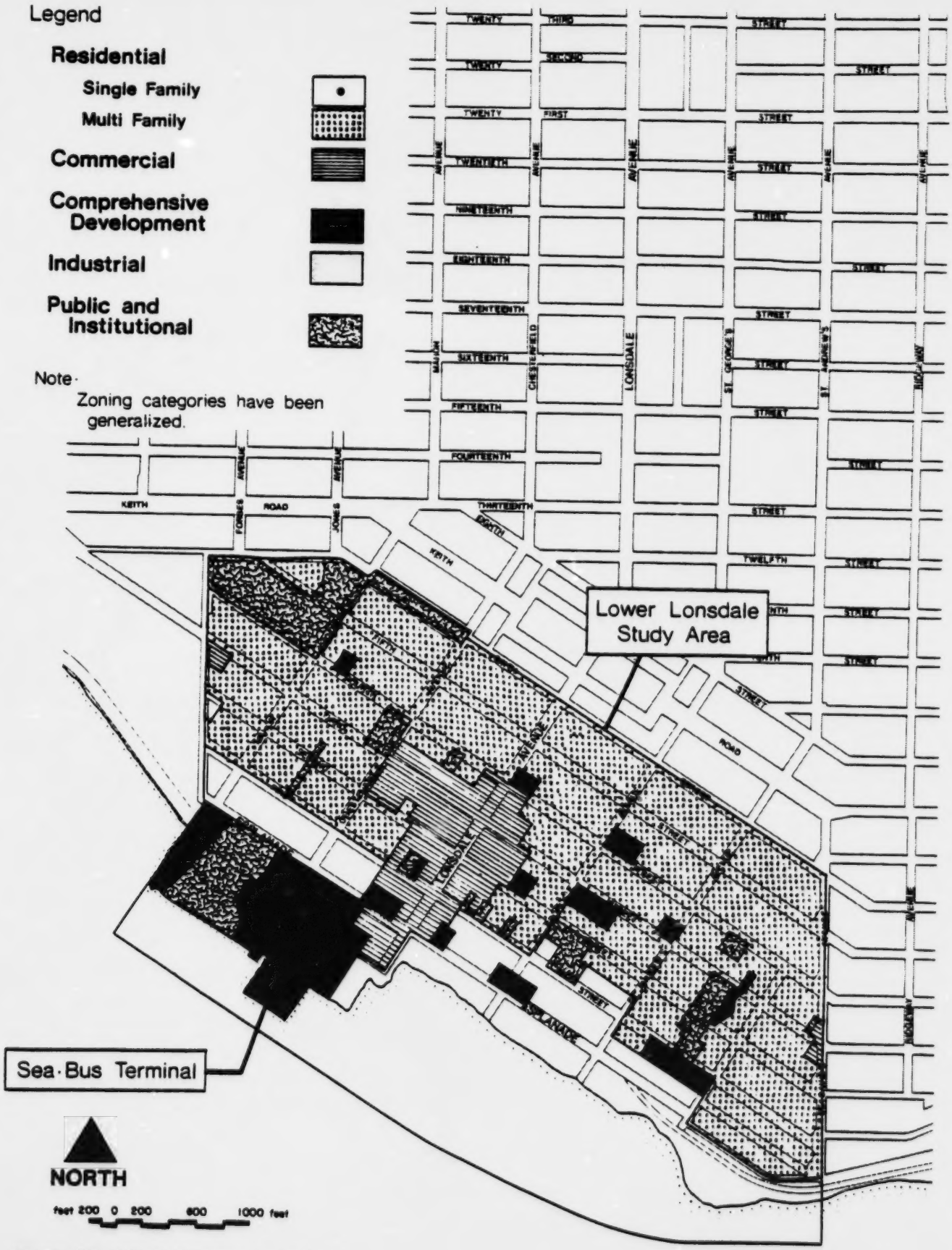
Residential policies in relation to the Mixed Use Area for Lower Lonsdale specify a range of multi-family housing along with retail and entertainment facilities. This suggests orientation towards the young and single population groups which in effect, tends to reinforce the role of Sea-Bus.

The section of the plan specifically devoted to Lower Lonsdale Redevelopment policies outlines more direct Sea-Bus influences. The specification of a pedestrian-oriented scale of development was intended to reinforce transit usage policies. This is further compounded by the discouragement of park and ride facilities and long



Source: Lower Lonsdale Waterfront Study City of North Vancouver · 1975.

Figure 26
Proposed Land Use



Source: City of North Vancouver Zoning Map Engineering Department - 1982.

Figure 27
Existing Zoning

term on-street parking. The plan also recognizes the importance of catering to commuters and tourists using Sea-Bus with a greater propability of impulse shopping while being routed through the area on foot.

Regarding employment policies, the introduction of the ferry terminal and re-routing of the public transit routes were viewed as major stimulants for the projected 5,000 new jobs in Lower Lonsdale (4,000 "foot-loose", 600 site oriented and 600 population-serving).

4.2.2 Zoning

In conjunction with the tailoring of Official Community Plan policies zoning amendents were made to accommodate provincial initiatives and expedite development in Lower Lonsdale. A series of Comprehensive Zones were created for the Lonsdale Quay development as illustrated in Figure 27.

Subsequent to the introduction of the Sea-Bus in 1977 most of the re-zoning involved changes from industrial zones to Comprehensive Development zones. A mix of retail, commercial and residential uses are permitted subject to Development Permits.

4.3 Urban Indicators

In a further attempt to determine the possible impacts of Sea-Bus on urban development in the Lower Lonsdale a number of quantifiable indicators have been analyzed. They include land values and revenues as well the value of building permits.

4.3.1 Land Values

Land in the immediate vicinity of the North Shore terminal increased in value from $4 million to $34.5 million between 1972 and 1982. As illustrated in Table 26, the average increase per annum in the this period was 26%, dropping to 22% per annum between 1978 and 1982. The value of property (land plus improvements) increased more dramatically in the latter period, reflecting improvements in the form of built space.

Year	Value ($ Million)	% Increased (Compounded)
1972	4.065	
1978	15.654	26%
1982	34.462	22%

Table 26 Land Values in the Immediate Terminal Area

Land values in other areas of Lower Lonsdale were increasing at less than half the rate of those in the terminal area (12% per annum)

between 1972 and 1978, but exhibited marked increases between 1979 and 1982 (31% per annum). Whether this latter trend was a reflection of increases in the terminal area or a result of the announcement of plans for redevelopment of the commercial core is not clear.

4.3.2 Municipal Taxation Revenues

The total annual taxation revenues garnered from the study area increased by 277% between 1976 and 1982 (refer to Table 1 in Appendix E). The City of North Vancouver's share increased from $269,000 to $1 million. Most of this increase occurred in the post-1979 period during which time the Lonsdale Quay development started contributing in a major way to property taxation. Revenues from both industrial and commercial properties during that period increased.

4.3.3 Building Permits

The value of building permits in the study area (Lower Lonsdale) is given in Table 2 in Appendix E. The most significant increase in the period 1976-1981 is associated with commercial activity. This is reflected in the new commercial developments on Lonsdale Quay and along Esplanade.

It is interesting to note that residential permit values show a substantial increase just two years after the provincial takeover of land. The effects of Sea-Bus on this activity is not known.

4.4 Housing and Population

Housing and population trends were examined in an attempt to determine the extent to which the socio-economic characteristics of the Lower Lonsdale area have been influenced by the introduction of the Sea-Bus service.

The planning and zoning amendments following the introduction of Sea-Bus encouraged greater residential, commercial and mixed uses in the terminal site area (now Lonsdale Quay). A Lower Lonsdale Renewal scheme adopted in 1968 had already specified a decrease in industrial activities and the creation of higher density residential uses. Although these zoning enactments were excluded from the terminal site, they reflect significant planning initiatives oriented toward increasing residential activity well before Sea-Bus was anticipated.

The number of new residential permits issued in 1976 (refer to Table 2 in Appendix E) may have been in response to the scale and type of development anticipated in Lonsdale Quay. It is also possible that the increased access to Downtown Vancouver as a result of Sea-Bus encouraged a portion of residential development particularly apartment rental accommodation. Rental accommodation between 1971 and 1976 increased from 49% to 79% as a result of large increases in the proportion of apartments in Lower Lonsdale. In 1971 43% of all dwellings were apartments while the figures for 1976 and 1981 were

88% and 89% respectively. Less than 10% of the housing stock comprises single family dwellings. Moreover, average number of persons per household dropped from 2.3 in 1971 to 1.9 in 1976 and 1.75 in 1981.

The results of a Sea-Bus interview program with a 145 sample population, indicated that the availability of Sea-Bus was an important consideration for 20% of the patrons regarding residential location. Although the response is relatively small it does suggest that the Sea-Bus may have had an indirect effect on residential location decisions. Based on the results of the Sea-Bus questionnaire survey, 587 passengers or 20% of the total sample walk directly to the Sea-Bus terminal from the North Shore. This has further implications regarding residential location decisions which could be partly attributable to Sea-Bus.

Population characteristics reflect significant changes in the Lower Lonsdale area between 1971 and 1981. They do not differ significantly from general regional trends.

There are several indicators which, when considered with recent empirical evidence, suggest that specific trends may be at least partially attributable to the introduction of Sea-Bus service. According to interviews with Sea-Bus passengers it seems that the service has a positive effect on inducing use for social, entertainment and recreational trips to Downtown Vancouver and in particular, the North Shore. A number of premises (restaurants, pubs, etc.) have been established near the terminal in the Lower Lonsdale area. This, coupled with the attractiveness to young single people of the large proportion of rental accommodation in the area has produced the following trends. The large age cohort (42.5%) is the 20-34 age group (1981). Approximately 64% of area households have no children, while 38% of those over 15 years of age are single and 69% of all households have only one occupant.

4.5 Conclusion

The introduction of the Sea-Bus service in 1977 was a provincial initiative which in isolation appears to have had few direct impacts on urban development on the North Shore. It is clearly evident that shortly after the provincial land assembly program in 1974 and proposal of a major transportation centre, local planning and zoning policies were changed to accommodate and focus development in the terminal area. It appears that these amendments were attributable primarily to the magnitude of development on Lonsdale Quay rather than to Sea-Bus as an insular activity. It can therefore be concluded that the Sea-Bus provided the critical link in the entire transportation proposal on the Quay and that this development was largely responsible for major changes in land use and zoning.

The commercial developments which occurred on Lonsdale Quay after the Sea-Bus service began seem to have been the result of a conscious

effort made by the government to stimulate growth and expedite development of Lower Lonsdale. The positive effects of this action are reflected in the revitalization of the area plus increased land values and municipal taxation revenues. The influence of Sea-Bus in light of all other activity in the area appears to have been minimal.

The recent establishment of small private businesses seem to be in response to the growing demand for social amenities in the area. Sea-Bus must certainly be considered a contributing factor to the establishment of these operations. The test of the Sea-Bus influence in the Lower Lonsdale area will be the success of the Lonsdale Quay development in attracting the desired mix of residents, employees, shoppers, tourists and those with recreational pursuits.

Experience in Toronto and other centres suggest that it normally takes between five and ten years for the full impact of such a service to be felt and, leading into year seven of Sea-Bus service, the major positive influences are becoming readily evident.

5.0 HARBOUR ENVIRONMENT

Included under this heading are the effects of the Sea-Bus on the marine environment during the construction phase of the operation and service implementation. The impact of vessel operations on shoreline properties as well as harbour traffic and navigation is also assessed.

5.1 Marine Environment

This section examines the impacts of the Sea-Bus system and operations on the environment in relation to water quality, air quality and shoreline habitat. Along with this the potential environmental impacts associated with the terminals, the vessels and maintenance procedures are discussed.

5.1.1 Terminals

The development of the Sea-Bus terminals required altering the foreshore and shoreline of each site area prior to construction. Information on the pre-construction habitat is generally not available. However, the surrounding shoreline consisting of rocks, boulders and fill is very similar to other habitats in the Inlet. It appears that the previous shoreline was not critical and it is unlikely that it was affected by construction activity. In fact, the untreated concrete bases of the floating terminals have improved the habitat by providing solid substrates for sessile benthic organisms (barnacles, mussels, etc.).

The storm drains installed at the North Shore bus loop are directly connected to Burrard Inlet and all drainage flows into the harbour. The catch basins are not equipped with oil traps to prevent bus oil leakage from entering the harbour. Although the presence of oil in the marine environment can have numerous effects, this source of oil is inconsequential compared to the amount washed into storm drains off city streets and rail yards. The relocation of the bus loop to the ICBC building may effectively eliminate this problem.

5.1.2 Vessels

Noise pollution can occur in both air and water. The noise level emitted by the Sea-Bus in the air inside and outside of the vessels has been measured and complies with government requirements.

The marine noise level created by the vessels has not been recorded. In consideration of the small number of marine mammals present in the harbour and the large number of other harbour vessels the contribution of Sea-Bus to submarine noise is probably negligible.

5.1.3 Maintenance

As part of the daily maintenance procedures the vessels are refueled with diesel fuel pumped from 45,500 litre storage tanks into two 3700

litre tanks on-board. Once a week lube oil is replenished and the Sea-Bus bilge water is pumped into a water/oil separator at the maintenance dock. In these instances, necessary precautions are taken to minimize the possibility of an environmental impact due to fuel spillage. There have been no incidents of fuel spillage in the harbour as a result of vessel maintenance. Other vessel repair work or painting which is done under controlled conditions, has not disrupted the environment.

Major janitorial servicing such as cleaning the inside of terminal facilities each night involves the use of industrial grade detergents. Any waste water, however, is vacumm pumped and discharged in the city sewage system. During the summer the vessels are periodically washed with TSP (tritonium phosphate). The infrequency of these washings results in a minimal impact of TSP in the harbour.

5.1.4 Conclusion

It can be concluded that the effects of the Sea-Bus and associated facilities on the environment are certainly negligible against the background of disturbance due to other activities in the harbour. In its present form and mode of operation, the Sea-Bus would have only a minimal impact on even a completely undisturbed environment with the possible exception of noise pollution. Hydrophone recordings would indicate if Sea-Bus noise contributes appreciably to the submarine noise levels. The overall conclusion is that safety precautions employed at terminals and during operation and maintenance have been effective in minimizing the impact of the Sea-Bus on the aquatic life of Burrard Inlet.

5.2 Vessel Operations

This section discusses the effects of Sea-Bus operations on properties near each of the terminal shore lines.

5.2.1 Property Damage

In the initial period of operation the Sea-Bus vessels were operating at a speed of about 13.5 knots. The wash generated at this speed, combined with the frequency of crossings, caused damage to water lot properties in close proximity to each terminal.

As a result of the wave action approximately 200 claims were brought against B.C. Hydro, who was in charge of Sea-Bus at the time. The most significant claims action was an injunction application initiated by six firms in the vicinity of the South Shore terminal. Consequently, course changes and terminal approach procedures were introduced along with a reduction of vessel speed to minimize the extent of damage. This was challenged by the complaintants who also filed suit for damages.

In March 1978 the six firms were awarded a total settlement of almost $55,000.

It is interesting to note that only one of the claims included damages for loss of business. The remainder entailed property damage to such items as floats, docks, tugs, scows, water taxis and aircraft. Incidents involving hazardous conditions for employees working facilities were also cited.

The only other well-documented reference to quantified business revenue losses ($40,000) was for damages to floats and foreshore facilities sustained at 600-berth marina on the North Shore. Subsequent to the claim federal fisheries authorities made arrangements to tow in a 180 metre long breakwater for the marina at a cost of $500,000.

5.2.2 Conclusion

The ramifications of the rash of wave action claims arising during the period following service initiation were threefold. Alterations in trans-inlet courses, terminal approach procedures and operating speeds have been mentioned. In addition, B.C. Hydro made arrangements to establish both a settlement fund for future claims related to operation of the service, and a committee to investigate and report on the effects of the wave action and possible remedial steps to be taken.

5.3 Harbour Traffic and Navigation

The designated Sea-Bus route and the frequency of crossings have created additional harbour traffic in a busy port situation. Regular service in conjunction with adverse weather and sea conditions can potentially affect safe navigation across the Inlet.

This section discusses the effects of Sea-Bus on other harbour traffic, including the changes made to accommodate the service. Sea conditions under which the service operates are also discussed since they constitute an important safety consideration in navigation.

5.3.1 Vessel and Float Plane Movement

The introduction of commuter ferry service on Burrard Inlet required a number of safety measures and regulations to minimize chances of collisions between Sea-Bus and other deep sea vessels and float planes.

The majority of vessel movement in the harbour consists of tugs with tows. As expressly stated in the operation regulations (refer to Appendix F), Sea-Bus ferries must give the right of way to all hampered vessels including tugs with tows. In addition, all deep sea commercial traffic arriving in or departing from the Port of Vancouver have the right of way over Sea-Bus traffic.

These regulations imply that Sea-Bus masters must assume the initial responsibility to remain clear of other vessels and yield to other traffic at all times.

The only potentially serious Sea-Bus incident to date involved a collision with a Naval vessel while it was on trials in dense fog conditions. No injuries or major damages resulted. The naval operator was responsible for this incident.

Most of the other reported incidents with Sea-Bus have been with small marine vessels. These incidents were commonly referred to as "near misses" with chartered yachts crossing the paths of the ferries departing from the south terminal.

There appears to be some concern as expressed by Tug Masters over the frequency of Sea-Bus crossings without adequate visible warning. When Sea-Bus ferries depart from the terminals the customary long blast from the vessels' whistle can not be heard in the wheelhouse of the tugs. This has not caused any incident to date but is an important concern.

The Port of Vancouver handles more float plane traffic than any other North American C[illegible] Table 27 illustrates the volume of movements over the period [illegible] to 1982. At present five major air carriers use the harbour. Casual and recreational flights also use the harbour on occasion.

	TOTAL MOVEMENTS	AV. MOVEMENTS PER DAY (May-Aug)	AV. MOVEMENTS PER DAY (Peak Month)
1977	47,513	172	182 (July)
1978	50,770	192	221 (July)
1979	62,703	251	291 (August)
1980	62,977	233	280 (July)
1981	51,165	175	188 (July)
1982	25,335	133	142 (July)

Table 27 Vancouver Harbour Float Plane Movement, 1977-1982

Aircraft movement in the harbour is not restricted except in the vicinity of the First and Second Narrows. Aircraft are encouraged to confine operations to Area Alpha, a designated landing and take-off area in the harbour. This area is well clear of the Sea-Bus route, but planes are permitted to move out of Area Alpha when visibility conditions so dictate.

Since the ferry service began some Sea-Bus operators have reported "close quarter" situations with float planes using Area Alpha. The actual nature of these incidents is not too clear. It seems agreed, however, that plane operations constitute a nuisance rather than a danger to ferry operations. There have been no reported incidents in recent months.

5.3.2 Sea Conditions

Sea-Bus operates in sheltered waters. Wind and wave actions in the Inlet are slight when compared to the more exposed waters of English Bay and Howe Sound. Even during the storm season, seas are minimal. On occasion, however, westerly winds against an ebb tide can cause an uncomfortable slop in the harbour.

The velocity and direction of tidal movements are generally not excessive in the area of the Sea-Bus route. Current and tidal movements essentially have no effect on the safety of the ferry operation.

5.3.3 Weather Conditions

Snow is infrequent and only the heaviest rainfall affects visibility to any marked degree. As a safety precaution during fog Sea-Bus is operated at reduced speed. Weather conditions have at no time caused the curtailment of Sea-Bus service and operations.

5.3.4 Conclusion

It can be concluded that the introduction of regular Sea-Bus service in the Inlet has had a minimal effect on pleasure craft and float planes which operate near the ferry route. These craft occasionally encroach into the Sea-Bus course but present no real danger to the safety of the operation. Moreover, prevailing sea conditions have little effect on the navigation and operation of Sea-Bus for safe, reliable and expedient crossing.

6.0 SUMMARY AND CONCLUSIONS

The findings of the impact evaluation imply that the major impacts of Sea-Bus are a function of its special character. The benefits of the high quality ride, service reliability and assured seating place Sea-Bus in a unique category of public transit.

This special quality of Sea-Bus has attracted regular patronage. Those who use it tend to be very satisfied with the service. The extra cost of Sea-Bus in comparison to a bus alternative is reflected in this quality.

Sea-Bus comprises only one segment in the overall transit system. As a third crossing, it plays a key role as a commuter facility. It allowed the removal of some bus transit across Lions Gate Bridge. This helped to relieve bus congestion at bus stops in Downtown Vancouver. Moreover, Sea-Bus presented the opportunity to re-design and improve the North Shore bus system. It has had a marginal impact on reducing automobile traffic on the bridge crossings.

Sea-Bus primarily serves a commuter market. It also encourages substantial ridership for recreational and shopping purposes. Harbour tours by Sea-Bus have become an important tourism component in the City. Also, Sea-Bus seems to have encouraged a portion of entertainment and retail developments around the North Shore terminal.

It can be concluded that Sea-Bus provides a special and necessary transit link connecting the North Shore to the City of Vancouver. It brings people who live on the periphery of Vancouver closer to their place of work in the Downtown. The unique travel experience of Sea-Bus has made it a special transit service. Sea-Bus meets certain trans-inlet travel needs in addition to providing an enjoyable mode of transit.

In summary, the main findings of the Sea-Bus impact evaluation study are:

- Sea-Bus passengers tend to incur greater origin-to-destination travel times than they would with competing modes.

- Sea-Bus ridership has increased slightly at an annual growth rate of 0.5%. Traffic across the bridges increased an average of 1.3% per year over the same period. The current economic downturn has affected Sea-Bus ridership less that it has affected traffic on the bridges.

- Sea-Bus primarily serves people who live on the North Shore and work in CBD of Vancouver. Its market share of traffic is about 7% during commuting hours and 5% for the day.

- About 57% of the Sea-Bus passengers used a bus before the service was introduced. In the am peak hour seven southbound buses were removed from Lions Gate Bridge as a result of Sea-Bus. This reduction in bus service amounted to a saving of 7500 km of bus travel.

- Sea-Bus has contributed to a 1% reduction of automobile traffic on the two bridge crossings.

- Sea-Bus presented the opportunity to re-design the North Shore bus system including better transfer connections to the ferry terminal. These improvements added 18,150 hours of new bus service.

- As part of the transportation system along with bus transit, Sea-Bus has not contributed directly to the cost efficiency of the system.

- Replacing Sea-Bus service with buses would require the addition of seven buses over the number running before Sea-Bus on Lions Gate Bridge in the am peak hour.

- The energy consumption of Sea-Bus is substantially greater than an alternative service by bus, but considerably less than an equivalent automobile service.

- Acquisition of the North Shore terminal site formed part of a major land assembly program (12 ha) initiated by the government in 1974, for the development of a major transportation centre. Sea-Bus provided the critical link in the development, now known as Lonsdale Quay. North Shore planning and development policies were tailored to accommodate the proposed development.

- The establishment of a number of social, retail and entertainment facilities near the North Shore terminal may in part be attributable to Sea-Bus.

- The major commercial developments on Lonsdale Quay appear to be the result of Government initiatives to stimulate growth in Lower Lonsdale. This is reflected in increases in taxation property values. Sea-Bus contributed in a small way to development of the Quay.

- The Sea-Bus system including terminals, vessels and maintenance procedures has not had any adverse effect on the marine environment of Burrard Inlet.

- Sea-Bus operations in a busy port necessitated regulations to minimize chances of any collision with other harbour vessels. Float plane movements are restricted to a certain area clear of the Sea-Bus route for take-off and landing.

. At the initial period of Sea-Bus operations the vessels were travelling at 13.5 knots. This speed in conjunction with the frequency of crossings produced a wake that caused some damage to shoreline properties. Changes in the course and a reduction of vessel speed to 12 knots has effectively minimized the problem.

6.1 Study Experience

The Sea-Bus study presented a valuable opportunity to document impacts of a rather unique transportation system. The approach taken was to address a range of impacts associated with one transportation link after five years of service. This type of approach towards impact evaluation studies is fairly common. However, it makes it difficult to obtain reliable data.

Since the Sea-Bus program began there has been no systematic method of inventorying possible areas of impacts at various stages before and after Sea-Bus implementation. This constrained the analysis of pre-construction and construction activities on the environment as well as urban development and employment at various levels. Moreover, there has been no systematic approach to collecting an accurate set of traffic count data over the same periods. Traffic counts were often estimated which tended to render the information base less reliable.

The time-series methodology used for analysis of urban development activities and trends was largely dependent on information availability and compatibility. It was difficult to gather accurate information on Sea-Bus impacts on land speculation and the establishment of retail and commercial facilities prior to, and immediately after, service implementation. It was also difficult to determine the effects of Sea-Bus on a variety of urban activities on the North Shore considering the number of other influencing factors. The move towards the suburbs was a common trend at the time Sea-Bus was introduced. The North Shore is also perceived as an attractive and desirable place to live.

The study presented a valuable learning experience for measuring and qualifying impacts attributable to Sea-Bus. Quantifiable data provided a useful tool to measure the magnitude of Sea-Bus traffic in the trans-inlet transportation system. However, the more intangible aspects of Sea-Bus, such as its attractiveness, were not easily quantifiable.

For accurate measurement of such impacts a more comprehensive interview program should have been initiated. Similarly, a detailed interview program with business owners, etc. near the terminals may have generated more insights into Sea-Bus impacts on urban development.

To provide a comprehensive evaluation of Sea-Bus impacts, a research program should have been initiated before the service started. This would have enabled a more systematic approach to data collection for the purpose of identifying and analyzing various conditions and trends over the years.

Appendix A Terminal Site Land Acquisition

1.1 North Shore Terminal

The assembly of land for the construction of the North Shore ferry terminal involved expropriation of 12 hectares of private and public property. The site comprised seven properties including one municipally held parcel and six private holdings.

The waterfront lots were under the ownership of the federal government through the National Harbours Board (NHB). One of the primary issues which emerged during the site assembly process concerned the lack of provincial mandate to expropriate federal holdings. The province, however, acquired use of the properties rather than ownerships. The National Harbours Board waterfront lot leases held by private firms were considered to have automatically expired with the provincial takeover and the conditions of the new leases were negotiated.

The provincial government, through the Department of Public Works, made arrangements for total payments of $9.4 million to negotiated arbitrated settlements for the site. One of the firms involved refused acceptance of any settlement and resisted all eviction attempts. However, through a province Order in Council their full title to the property was reinstated in December 1982.

1.1.1 Business and Resident Relocation

Of the six private properties involved in the expropriation proceedings, two parcels were being held for development and four supported viable business operations and employed about 35 people.

Two of the four firms, Ocean Cement Ltd. (Lumber and Construction Materials) and Stork Werkspoor Canada Ltd. (Engineering and Architectural Services), relocated to Richmond and to another nearby North Vancouver location respectively. Ocean Cement retained its complement of approximately 18 employees but ceased operations, at least under the name, within three or four years. To attribute this result to the effects of relocation would be somewhat speculative at best. Stork Werkspoor effected a marginal decrease in its staff and is still in operation in North Vancouver.

The third firm, C.H. Cates and Sons Ltd. (Towing and Tugboat Service) continued its operation under threat of eviction, refused any cash settlement for expropriation, and had its titular rights to the property reinstated as recently as December 1982.

The uncertain nature of Cates tenure status resulted in difficulties for the firm with respect to conducting operations and planning expansions. Subsequent to the issuance of expropriation notices,

Cates has purchased two new tugs and anticipated further enlarging its fleet and improving or expanding tug moorage and related marine way and office facilities. However, lack of confirmation as to possible relocation requirements necessitated curtailment of such proposals. This situation persisted until the reinstatement of the firms title to the property.

The fourth operation was located on the Northern Waterfront Holdings water lot and included a marina and docking facilities accommodating approximately 40 craft of the Chesterfield Dock Boat Owners Association. A large proportion were live-a-board vessels, and considered as residences.

The marina and dock were expropriated in March 1974. Owners were orginally issued eviction notices in November 1974 and requested to vacate by January 1975. After an appeal to the Province, those owners adjudged to be bonafide tenants were permitted to retain use of the facility under the condition that they would vacate the area when the Ministry implemented the terminal construction plans.

To further accommodate the tenants the dock was removed and relocated to the west in March 1976 at the expense of the Province which subsequently entered into formal individual agreement with the tenants as to their use of facility. The agreement stipulated that the boat owners could retain use of the area without rental charges but that they were to make their own arrangements for electricity supply and make effort to find new berths and vacate by September 1976. The terms of the agreement was apparently extended but in March 1978, when grading of lands adjacent to the terminal began, notice to vacate within 14 days was issued to the remaining 32 owners.

1.1.2 Loss of Development Opportunities

Arpro Developments Ltd. held development rights on 6.8 ha of Seaspan property between Lonsdale Avenue and Chesterfield Avenue. A $25 million development proposal for the parcel, including a marina and convention centre had received approval in principal from the City of North Vancouver in January, 1974 but was subject to a Land Use Contract (site plan agreement). Expropriation notices were issued before further action on the proposal was taken. Arpro took the case to arbitration under the Public Works Act and received compensation of $2.2 million which constituted approximately 23% of the total settlement for the seven properties.

In addition to the short term loss of development opportunities experienced by the private sector, the City of North Vancouver was also affected with respect to anticipated taxation revenues from the Arpro development. Although the municipality may ultimately recoup those immediate losses in the longer term as the Lonsdale Quay development proceeds, the quashing of the original proposal had the immediate effect of deferring such revenues.

1.2 South Shore Terminal

Regarding the South Shore terminal, the NHB agreed to the plans for the required water lots as it had for the northern terminal. Negotiations for the remainder of the site involved Marathon Realty, CP Rail and Project 200.

Marathon Realty, as the real estate arm of CP Rail, was responsible for allowing the use of the station building through which the terminal is accessed and within which space rental was arranged.

Marathon and Project 200 were responsible for allowing the use of air space through which the bridge connecting the station with the escalator leading to the floating terminal pass. Agreement as to the creation and use of the necessary strata lots was arranged to ensure that ferry passengers would be routed through the final commercial structure (the product of Marathon's renovation scheme for the station building).

CP Rail was responsible for allowing installation of the structures supporting the aforementioned pedestrian bridge.

Leasing negotiations were conducted on the basis of the use of 2500 square metres of the CPR Station concourse space.

1.1.2 Major Changes in Bus Routes and Services

. Cancellation of 13 express bus trips to Vancouver.

. North Shore Cross-town Service improved to provide 15 minute service intervals, and the route extended to include the former "#215 Lillooet".

. #232 Queens improved to provide 15 minute peak hour service between Kootenay loop and 15th and Lonsdale.

. #214 Berkley improved to provide 15 minute peak hour service.

. Sea-Bus feeder routes with transfer service include the #228 Lynn, #229 Westlynn, #246 Highland, #230 Lonsdale, #238 Grand Boulevard and #236 Pemberton. Route #240 Marine Drive provides a eastbound corridor to Sea-Bus.

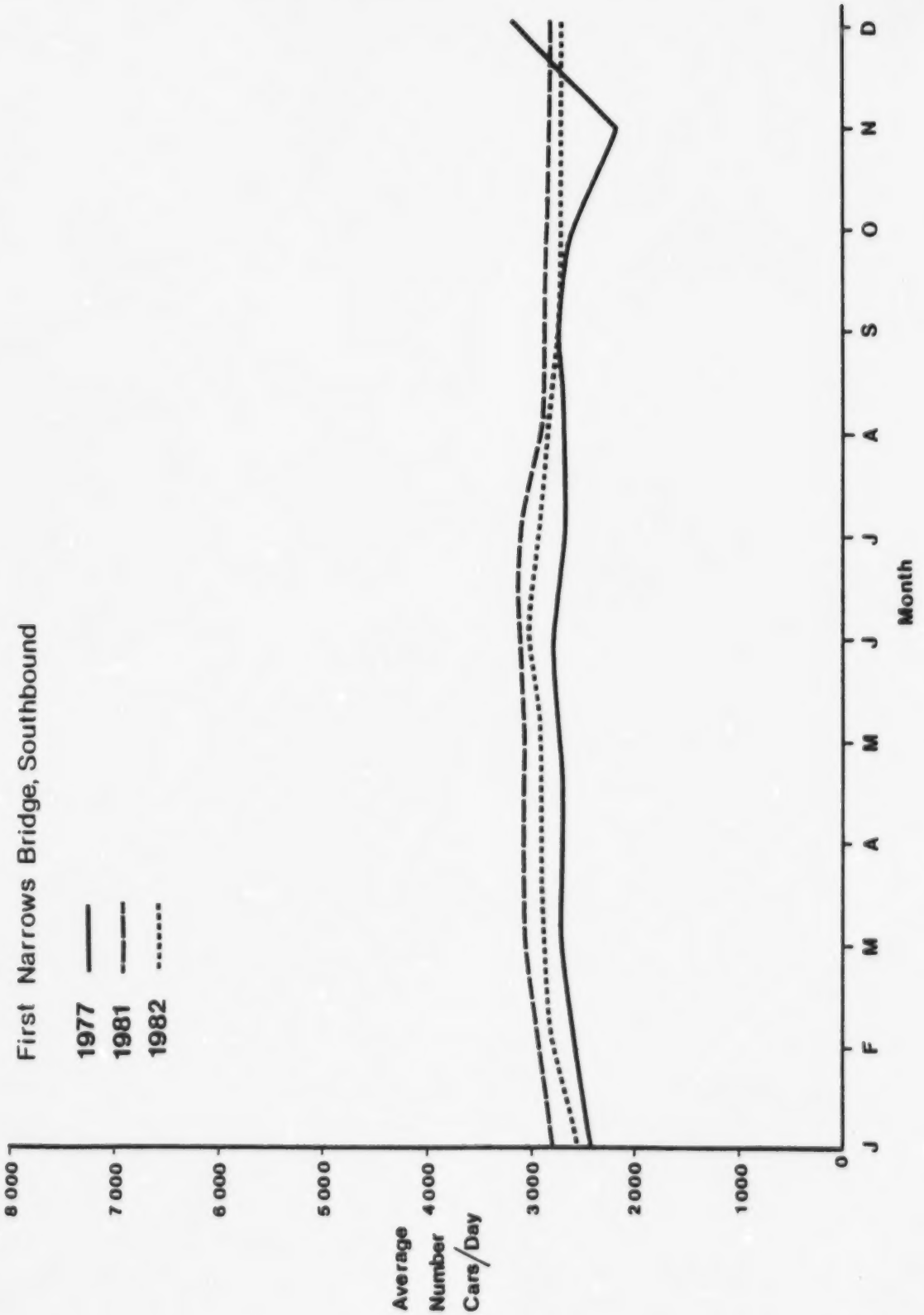
. New routes and services providing increase service coverage linkages to Sea-Bus include the portion of route #229 Westlynn on 29th Street, the increased service level on the eastern portion of #229 to Duval to Phibbs exchange, the Braemar route on #230 Lonsdale, and peak period service on route #247 Capilano.

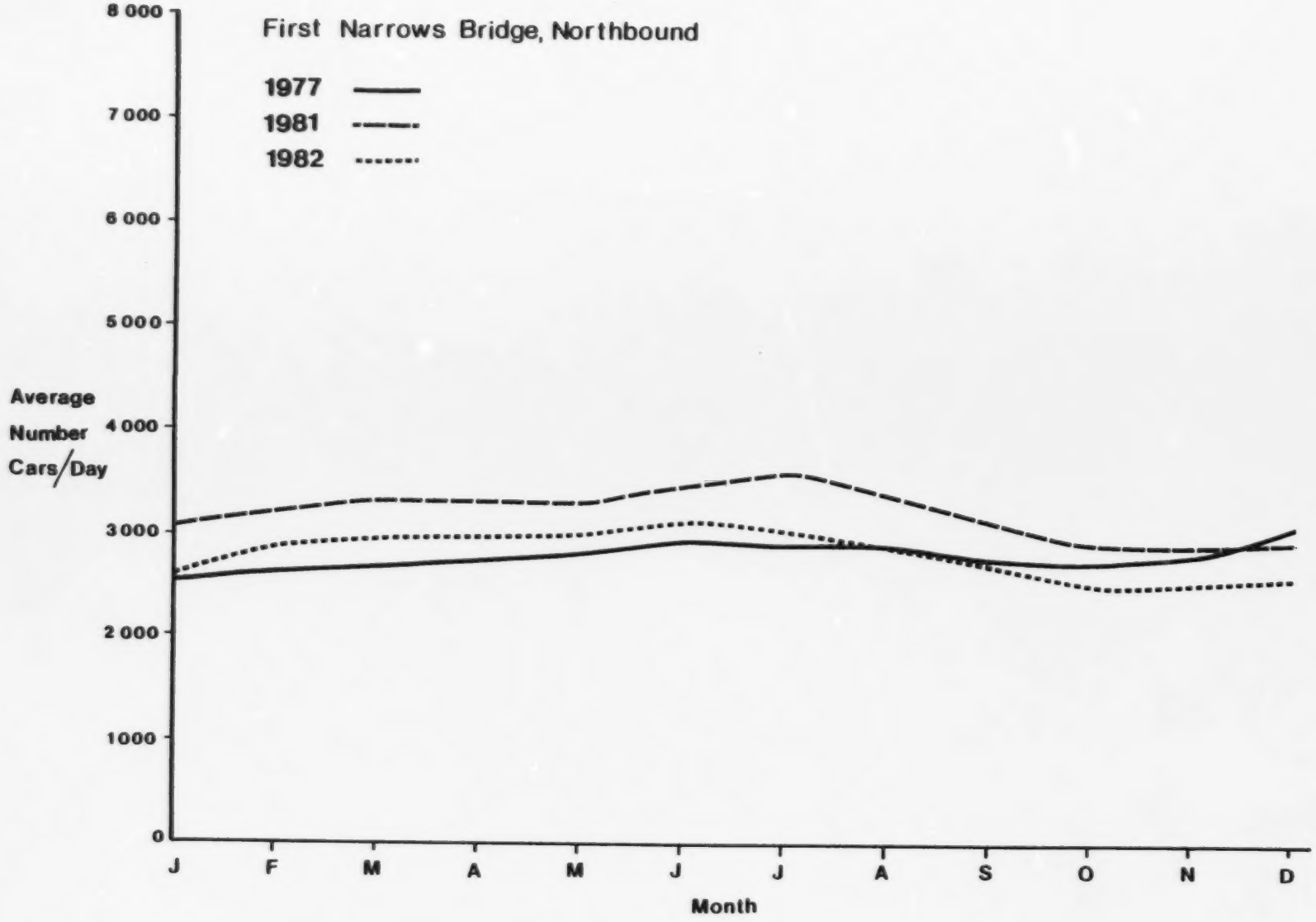
. New series of 240 routes via the First Narrows Bridge include #240 Marine Drive, routes #241 and #242 Upper Lonsdale, route #246 Highland and route #247 Capilano. Route #240 Marine Drive and #246

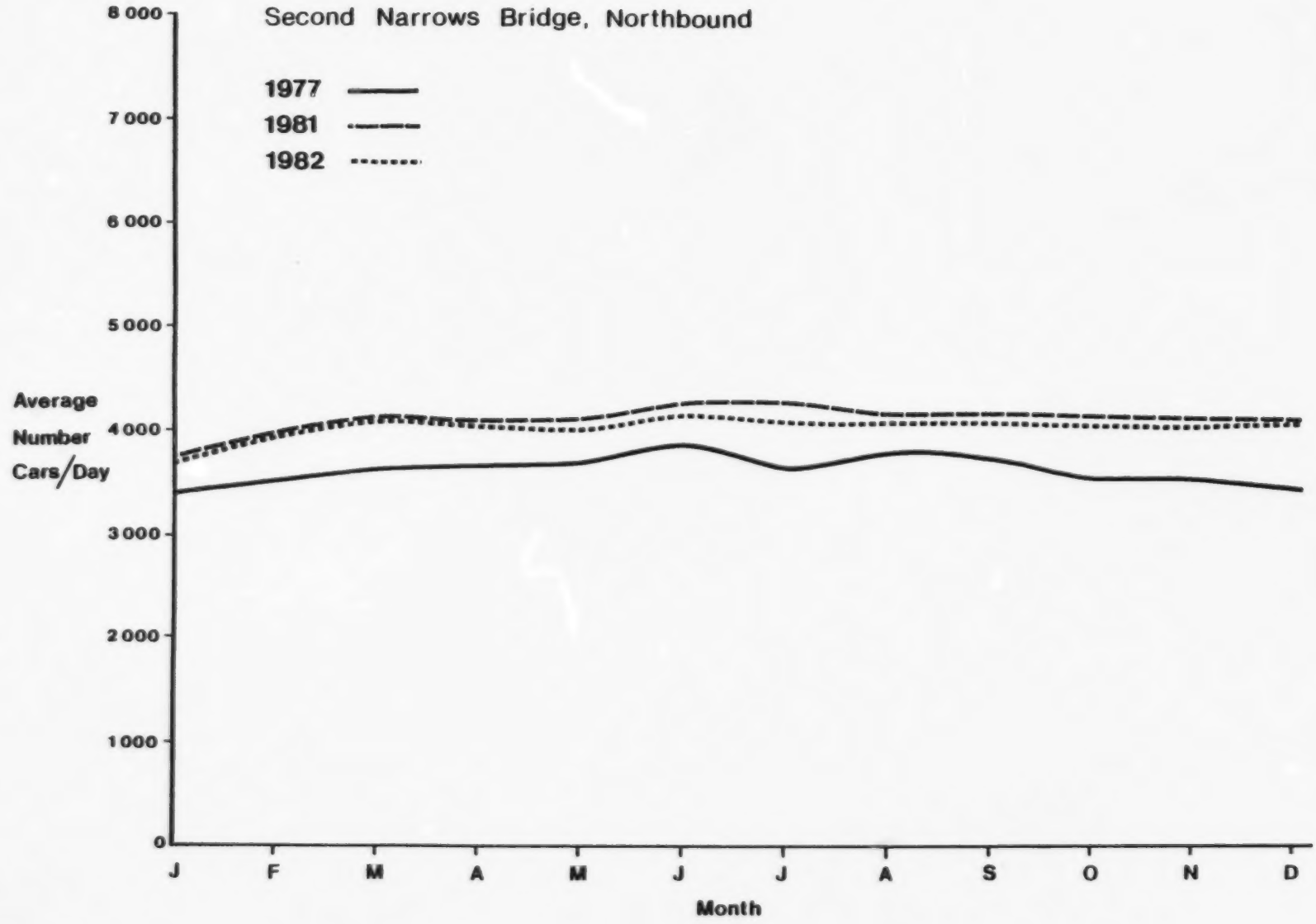
Highland also connect to Sea-Bus, providing an east-west residential corridor.

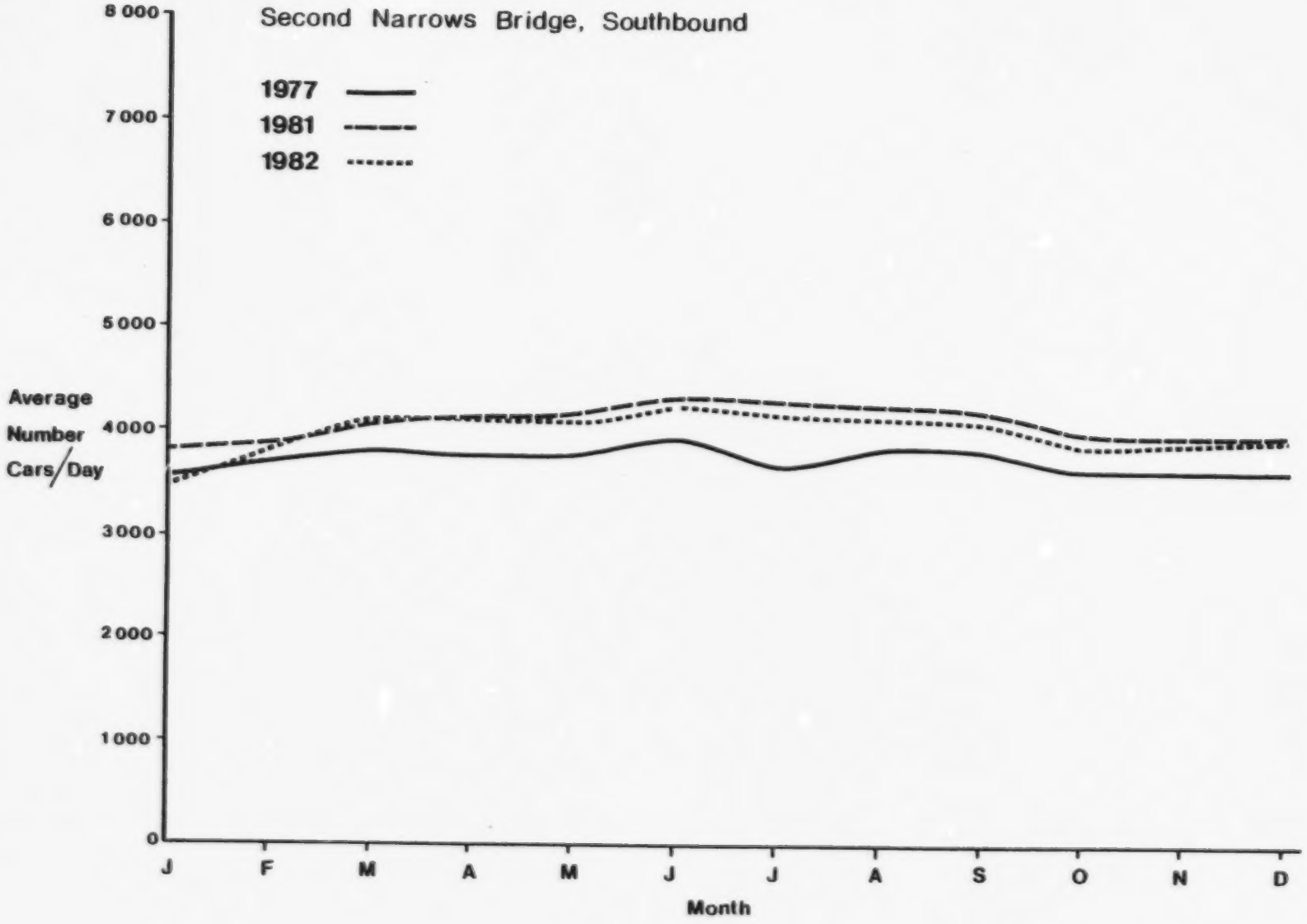
- Route #246 has been recently changed (September 1982) to operate to Park Royal in the off-peak hours. The 240 series of routes discharge passengers only inbound within Vancouver on West Georgia Street and pick up passengers only outbound on West Georgia Street. No passengers enter inbound within Vancouver or exit outbound within Vancouver.

Appendix B Monthly Annual Daily Travel Patterns on First and Second Narrows Bridges (1977-1981)




First Narrows Bridge, Northbound
1977
1981
1982
8 000
7 000
6 000
5 000
4 000
3000
2 000
1000
0
Average Number Cars/Day
J
F
M
A
M
J
J
A
S
O
N
D
Month


Second Narrows Bridge, Northbound
1977
1981
1982
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
0
Average Number Cars/Day
J
F
M
A
M
J
J
A
S
O
N
D
Month


Second Narrows Bridge, Southbound
1977
1981
1982
8 000
7 000
6 000
5 000
4000
3000
2 000
1 000
0
Average Number Cars/Day
J
F
M
A
M
J
J
A
S
O
N
D
Month

Appendix C Passenger Survey Form and Results

1.1

SEA·BUS PASSENGER SURVEY

The purpose of this survey is to collect information about your journey today using the SEA-BUS in order to determine how well SEA-BUS is meeting the needs of its users. All answers are confidential. PLEASE FILL OUT QUESTIONNAIRE DURING YOUR SEA-BUS TRIP TODAY AND DROP IN THE BOX PROVIDED AT THE UNLOADING TERMINAL ON THE OTHER SIDE.

1) HAVE YOU FILLED OUT THIS QUESTIONNAIRE EARLIER THIS WEEK? (please circle appropriate number)

1. yes 2. no

If you answered YES, please drop in the box provided. If you answered NO, please continue.

2) WHAT IS THE PURPOSE OF YOUR TRIP TODAY? (please circle appropriate number)

1. work
2. shopping
3. personal business (medical, dental, etc.)
4. social or recreation
5. school, college or university
6. home
7. other _____ (specify)

3) WHERE DID YOU BEGIN YOUR TRIP TODAY?

_____ OR
Street address or nearest intersection

☐☐ _____ AND
Name of firm, building, etc.

_____
Municipality

4) AT WHAT TIME DID YOU LEAVE THIS ADDRESS?

_____ a.m./p.m.

5) HOW DID YOU GET TO THE SEA-BUS TERMINAL? (please circle appropriate number)

1. walk
2. car driver
3. car passenger
4. bus, no transfer
5. bus, with a transfer
6. part way by car, part way by bus
7. taxi
8. other _____ (specify)

6) WHERE ARE YOU GOING TODAY?

_____ OR
Street address or nearest intersection

☐☐ _____ AND
Name of firm, building, etc.

_____
Municipality

7) AT WHAT TIME DO YOU EXPECT TO ARRIVE AT THIS ADDRESS?

_____ a.m./p.m.

8) HOW WILL YOU GET FROM THE SEA-BUS TERMINAL TO YOUR FINAL DESTINATION? (please circle appropriate number)

1. walk
2. car driver
3. car passenger
4. bus, no transfer
5. bus, with a transfer
6. part way by car, part way by bus
7. taxi
8. other _____ (specify)

9) HOW MANY ONE-WAY TRIPS DO YOU MAKE BY SEA-BUS? (please circle appropriate number; count a round trip as two one-way trips)

1. 8 or more per week
2. 1 to 7 per week
3. 1 to 4 per month
4. less than 1 per month

OVER ➡

10) HOW DID YOU MAKE THIS TRIP BEFORE SEA-BUS EXISTED? (please circle appropriate number)

1. as a car driver
2. as a car passenger
3. by bus, no transfer
4. by bus, with a transfer
5. part way by bus, part way by car
6. did not make the trip (please go on to question 12)
7. other _____ (specify)

11) IF YOU MADE THIS TRIP BEFORE SEA-BUS EXISTED, DID IT REQUIRE: (please circle appropriate number)

1. less overall time
2. more overall time
3. the same time
4. do not know

12) IS THERE A CAR AVAILABLE TO YOU WHICH COULD HAVE BEEN USED FOR THIS TRIP? (please circle appropriate number)

1. yes
2. no (please go on to question 14)

13) IF A CAR IS AVAILABLE TO YOU FOR THIS TRIP, WOULD IT REQUIRE: (please circle appropriate number)

1. less overall time
2. more overall time
3. the same time
4. do not know

---

14) IN ORDER TO CORRELATE RESULTS WOULD YOU PLEASE CIRCLE APPROPRIATE NUMBER BELOW.

a) Sex:
1. Male
2. Female

b) Age:
1. 0-14
2. 15-24
3. 25-44
4. 45-64
5. 65 and over

c) Total Household Income:
1. 0-9,999
2. 10,000-14,999
3. 15,000-24,999
4. 25,000-34,999
5. 35,000-44,999
6. 45,000 and over

15) IN THE SPACE BELOW PLEASE SUGGEST ANY IMPROVEMENTS YOU WOULD LIKE TO SEE MADE IN SEA-BUS SERVICE OR BUS SERVICE PROVIDED TO AND FROM THE FERRY TERMINALS.

THANK YOU FOR YOUR CO-OPERATION!

PLEASE DROP IN THE BOX PROVIDED WHEN YOU LEAVE

Lowndes

1.2 Survey Results

Response Rate

DIRECTION	RESPONSE	(PERCENT)
Southbound ********** Northbound **********	2837 2676	(51.5) (48.5)

0 1000 2000 3000
Frequency

TOTAL RESPONSES 5513

DAY OF WEEK	RESPONSE	(PERCENT)
Wed Mar 23, 1983 ********** Thu Mar 24 ********** Fri Mar 25 ********** Sat Mar 26 **********	2042 1494 1048 929	(37.0) (27.1) (19.0) (16.9)

0 1000 2000
Frequency

TOTAL RESPONSES 5513

Origin/Destination Mode

ORIGIN MODE	RESPONSE	(PERCENT)
Walk **********	1451	(26.6)
Car Drive *********	413	(7.6)
Car Passenger *******	353	(6.5)
Bus, No Transfer **********	1188	(21.8)
Bus, With Transfer **********	1686	(30.9)
Car and Bus **	84	(1.5)
Taxi *	39	(0.7)
Other *****	243	(4.4)
0 400 800 1200 1600 2000 Frequency		

TOTAL RESPONSES 5457
MISSING CASES 56

DESTINATION MODE	RESPONSE	(PERCENT)
Walk **********	2114	(38.8)
Car Driver ****	148	(2.7)
Car Passenger *****	154	(2.8)
Bus, No Transfer *********	829	(15.2)
Bus, With Transfer **********	1899	(34.8)
Car And Bus **	35	(0.6)
Taxi *	30	(0.6)
Other ******	243	(4.5)
0 1000 2000 3000 Frequency		

TOTAL RESPONSES 5452
MISSING CASES 61

Trip Purpose and Frequency

TRIP PURPOSE	RESPONSE	(PERCENT)
Work **********	2309	(43.7)
Shopping *******	653	(12.4)
Personal Business ****	353	(6.7)
Social Or Recreation *********	963	(18.2)
School Or College *****	338	(6.4)
Home ******	405	(7.7)
Other ***	259	(4.9)
0 1000 2000 3000 Frequency		

TOTAL RESPONSES 5280
MISSING CASES 233

FREQUENCY OF RIDE	RESPONSE	(PERCENT)
9 Or More Per Week **********	1733	(32.4)
1 To 7 Per Week **********	1483	(27.7)
1 To 4 Per Month **********	1001	(18.7)
Less Than 1 Per Month **********	1134	(21.2)
0 400 800 1200 1600 2000 Frequency		

TOTAL RESPONSES 5351
MISSING CASES 162

Car Alternative

CAR AVAILABILITY	RESPONSE	(PERCENT)
Yes **********	2739	(52.7)
No **********	2458	(47.3)
0 1000 2000 3000 Frequency		

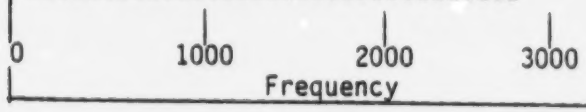
TOTAL RESPONSES 5197
MISSING CASES 316

CAR TRAVEL TIME	RESPONSE	(PERCENT)
Less Overall Time **********	1635	(46.3)
More Overall Time ********	842	(23.9)
The Same Time *******	581	(16.5)
Do Not Know ******	471	(13.3)
0 400 800 1200 1600 2000 Frequency		

TOTAL RESPONSES 3529
MISSING CASES 1984

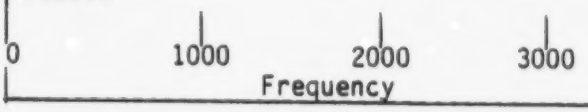
Personal Profile

SEX	RESPONSE	(PERCENT)
Male	2561	(47.8)
Female	2792	(52.2)



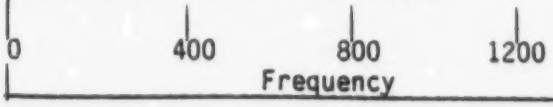
TOTAL RESPONSES 5353
MISSING CASES 160

AGE	RESPONSE	(PERCENT)
14 And Under	163	(3.0)
15 - 24	1595	(29.8)
25 - 44	2445	(45.7)
45 - 64	896	(16.7)
65 And Over	256	(4.8)



TOTAL RESPONSES 5355
MISSING CASES 158

TOTAL HOUSEHOLD INCOME	RESPONSE	(PERCENT)
Less Than 10,000	664	(14.1)
10,000 - 14,999	603	(12.8)
15,000 - 24,999	1016	(21.6)
25,000 - 34,999	863	(18.4)
35,000 - 44,999	650	(13.8)
45,000 And Over	903	(19.2)



TOTAL RESPONSES 4699
MISSING CASES 814

Trip Origin

GEOGRAPHICAL ZONE (refer to map)		RESPONSE	(PERCENT)
******************	1.	492	(10.1)
*****	2.	176	(3.6)
*********	3.	226	(4.6)
****	4.	130	(2.7)
***	5.	101	(2.1)
**	6.	66	(1.4)
*	7.	16	(0.3)
*	8.	38	(0.8)
******	9.	135	(2.8)
**	10.	52	(1.1)
**	11.	62	(1.3)
*	12.	1	(0.0)
*	13.	38	(0.8)
*	14.	35	(0.7)
*	15.	16	(0.3)
**	16.	54	(1.1)
*	17.	20	(0.4)
**	18.	47	(1.0)
*	19.	1	(0.0)
**	20.	85	(1.7)
*	21.	8	(0.2)
**	22.	65	(1.3)
*********	23.	224	(4.6)
************************	24.	657	(13.5)
**********	25.	353	(7.3)
**********************************	26.	912	(18.7)
******************	27.	423	(8.7)
********************	28.	435	(8.9)

0 200 400 600 800 1000
Frequency

TOTAL RESPONSES 4868
MISSING CASES 645

Trip Destination

GEOGRAPHICAL ZONE (refer to map)		RESPONSE	(PERCENT)
**********	1.	1497	(31.3)
***	2.	101	(2.1)
**********	3.	994	(20.8)
****	4.	195	(4.1)
**	5.	61	(1.3)
**	6.	63	(1.3)
*	7.	6	(0.1)
*	8.	24	(0.5)
***	9.	144	(3.0)
*	10.	20	(0.4)
*	11.	34	(0.7)
*	12.	11	(0.2)
*	13.	26	(0.5)
*	15.	6	(0.1)
*	16.	20	(0.4)
*	17.	5	(0.1)
*	18.	13	(0.3)
*	19.	4	(0.1)
**	20.	50	(1.0)
*	21.	23	(0.5)
**	22.	54	(1.1)
***	23.	126	(2.6)
*******	24.	373	(7.8)
***	25.	151	(3.2)
**********	26.	480	(10.0)
***	27.	128	(2.7)
*****	28.	180	(3.8)

0 400 800 1200 1600
Frequency

TOTAL RESPONSES 4789
MISSING CASES 724

1.3 Interview Questionnaire

DAY:
TIME:
NORTHBOUND

SEA-BUS PASSENGER SURVEY

EXCUSE ME, I'M _____. WE ARE CONDUCTING A SURVEY TO FIND OUT SOME OF THE IMPACTS OF SEA-BUS SINCE IT HAS BEEN IN OPERATION. ARE YOU ABLE TO SPEND SOME TIME WITH ME TO HELP IN THIS SURVEY? (circle appropriate numbers)

1. yes
2. no

1) WHAT IS THE PURPOSE OF YOUR TRIP TODAY?

1. work
2. shopping
3. personal business (medical, dental, etc.)
4. social or recreation (visiting friends, etc.)
5. school, college or university
6. home
7. other _____ (specify)

2) WHERE DID YOU BEGIN YOUR TRIP TODAY?

nearest street intersection _____ OR
name of firm, buiding, etc. _____ AND
municipality _____

3) HOW DID YOU GET TO THE SEA-BUS TERMINAL?

1. walk
2. car driver
3. car passenger
4. bus, no transfer (bus no. or name _____)
5. bus, with no transfer (bus no(s) or name(s) _____)
6. part way by car, part way by bus (bus no(s) or name(s) _____)
7. taxi
8. other _____ (specify)

4) WHERE ARE YOU GOING TODAY?

nearest street intersection _____ OR
name of firm, building etc. _____ AND
municipality _____

5) HOW WILL YOU GET FROM THE SEA-BUS TERMINAL TO YOUR FINAL DESTINATION?

1. walk
2. car driver
3. car passenger
4. bus, no transfer (bus no. or name _____)
5. bus, with transfer (bus no(s) or name(s) _____)

7. taxi
8. other _____ (specify)

6) HOW OFTEN DO YOU SHOP IN THE NORTH SHORE AREA ON YOUR WAY TO OR FROM SEA-BUS TERMINAL?

1. never (go on to question 9)
2. more than 3 times a week
3. once or twice a week
4. less than once a week

WHERE DO YOU USUALLY SHOP?

1. Lower Lonsdale (south of Victoria Park)
2. Upper Lonsdale (north of Victoria Park)
3. Park Royal
4. Lynn Valley
5. Edgemont
6. other _____ (specify)

7) DOES THE AVAILABILITY OF SEA-BUS INFLUENCE WHERE YOU SHOP?

1. yes .... in what way?
   Do you shop more often near Sea-Bus Terminal?
2. no

8) WHAT DO YOU USUALLY SHOP FOR IN THE SPECIFIED SHOPPING AREA?

1. groceries
2. clothing
3. household goods
4. novelty items
5. other _____ (specify)

9) HOW OFTEN DO YOU SHOP IN DOWNTOWN VANCOUVER OR YOUR WAY TO OR FROM SEA-BUS TERMINAL?

1. never (go to question 12)
2. more than three times a week
3. once or twice a week
4. less than once a week

WHERE DO YOU USUALLY SHOP?

1. Sears
2. Granville Street
3. Pacific Centre
4. other _____ (specify)

10) DOES THE AVAILABILITY OF SEA-BUS INFLUENCE WHERE YOU SHOP?

1. yes .... in what way?
   Do you shop more often near Sea-Bus Terminal?
2. no

11) WHAT DO YOU USUALLY SHOP FOR IN DOWNTOWN VANCOUVER?

1. groceries
2. clothing
3. household goods
4. novelty items
5. other _____ (specify)

12) HAS THE AVAILABILITY OF SEA-BUS INFLUENCED YOUR DECISION REGARDING .....

(a) the location of your workplace?

1. yes ... in what way?
2. no

(b) where you live?

1. yes ... in what way?
2. no

(c) leisure time activities?

1. yes ... in what way?
2. no

13) WOULD YOU LIKE TO HAVE BROUGHT YOUR BICYCLE ON THIS TRIP?

1. yes
2. no

14) DO YOU HAVE ANY PROBLEMS USING SEA-BUS?

1. yes ... indicate problems
2. no

15) PLEASE SUGGEST ANY IMPROVEMENTS YOU WOULD LIKE TO SEE MADE IN SEA-BUS SERVICE AND FACILITIES OR BUS SERVICE PROVIDED TO AND FROM THE TERMINAL.

16) THANK YOU

Appendix D. Weekday Bus Service Before and After the Introduction of Sea-Bus in June 1977

1.0 North Vancouver Bus Service Before Sea-Bus (Typical Weekday Service)

Route No.	Name	Peak Frequency	Off-Peak Frequency	(Replaced by)	Notes
80/81*	Lonsdale	10 min.	20 min.	241/242	(1)
81*	Vancouver Express	10 min.	------	Cancelled	(2)
82/81*	Third St.	7/8 min.	20 min.	238/240	(1)
83	Lynn Valley	10 min.	20 min.	228	(1)
84*	15th To Lonsdale	------	20 min.	240	
85	Delbrook	(2 trips)	------	Cancelled	
85/86*	Highland-Park Royal	10 min.	30 min.	246	(3)
88	McKay	20 min.	30 min.	236	(6)
89 K	Queens	30 min.	30 min.	232	
93	Westlynn	------	60 min.	229	
211P/911**	Seymour	30 min.	60 min.	211	
212 P	Dollarton	30 min.	60 min.	212	
214P/714*	Berkley	30 min.	30 min.	214	
215/239**	Lillooet/Crosstown	30 min.	30 min.	239	(4)
910**	Mountain Highway	15 min.	30 min.	210	
926	UBC Fastbus via 3rd	(3 trips)	------	286	(5)

* Via First Narrows Bridge to Vancouver Bus Depot.
** Via Second Narrows Bridge to Vancouver C.B.D.

P Route Terminal at Phibbs Exchange
K Route Terminal at Kootenay Loop
(1) Buses were signed "81" inbound to Vancouver
(2) Thirteen (13) expressed trips from Lonsdale during a.m. peak period
(3) To Park Royal in off-peak only
(4) To Phibbs Exchange only from Lillooet after 9:00 p.m.
(5) Re-routed from Highland after Sea-Bus
(6) 20 minute a.m. peak frequency; 30 minute p.m. peak frequency

1.1 North Vancouver Bus Service After Sea-Bus (Typical Weekday Service)

Route No.	Name	Peak Frequency	Off-Peak Frequency	(Replaced by)	Notes
210**	Mountain Highway	15 min.	30 min.	910	
211 N	Seymour	30 min.	60 min.	211/911	
212 P	Dollarton	30 min.	60 min.	212	
214 N	Berkley	15 min.	30 min.	214/714	
228 S	Lynn Valley	15 min.	30 min.	83/81	
229 S	Westlynn	15 min.	30 min.	93/New	
230 S	Lonsdale	15 min.	30 min.	New	(1)
232 K	Queens	15/30 min.	30 min.	89	
236 S	Pemberton Heights	30 min.	30 min.	88/New	
238 S	Grand Boulevard	15 min.	30 min.	82/New	
239	Cross-Town	15 min.	15/30 min.	239	(2)
240* S	Marine Drive	10 min.	30 min.	81	
241*	Upper Lonsdale	10 min.	30 min.	80/81	
242*239**	Upper Lonsdale via 3rd	------	(3 late trips)	80/81	
246* S	Highland	10 min.	30 min.	81/85/86	(3)
247*	Capilano	30 min.	------	89/New	
286	UBC/Highland Bus	60 min.	------	926/New	

** Via Second Narrows Bridge to Vancouver C.B.D.
* Via First Narrows Bridge to Vancouver Bus Depot

N Via Second Narrows Bridge to Vancouver C.B.D. peak hours only
S Route connects with Sea-Bus at Lonsdale Quay
P Route Terminal at Phibbs Exchange
K Route Terminal at Kootenay Loop
(1) Serves a portion of old route #80
(2) Freqency on Park Royal-Lonsdale Quay Section is every 15 minutes during off-peak hours
(3) To Park-Royal off-peak in September 1982

1.2 Trans-inlet Bus Trips to Vancouver (Typical Weekday Service)

Route No.	FIRST NARROWS Before Sea-Bus	FIRST NARROWS After Sea-Bus	SECOND NARROWS Before Sea-Bus	SECOND NARROWS After Sea-Bus
80/81/84	96 (a)			
82/81	62			
83/81	10			
85/86	22			
286		5		
714			6 (b)	
910			45	
911			6 (b)	
926	6			
89			39	
210				39
211				6
214				7
232				50
240		37		
241		45		
242		2		
246		58		
247		7		
TOTAL	196	154	96	102

(a) Includes thirteen (13)
(b) All express trips

Appendix E Taxation Revenues in North Vancouver and Building Permits Issued in Lower Lonsdale

	Revenue ($000's)					
Category	Study Area			Upper Lonsdale Core		
	1976	1979	1982	1976	1979	1982
Business Assessment	636.64	451.11	2,519.10	393.50	516.20	999.10
Industrial Assessment	185.19	405.12	554.20	-	-	-
Total Business/Industrial	821.83	856.23	3,063.30	393.50	516.20	949.10
Total Municipal Share	269.10	259.50	1,023.40	138.40	177.50	223.55

Table 1 Taxation Revenue Comparison in the City of North Vancouver.

Year and Type of Permit	Commercial		Industrial		Residential and Other	
1971	No.	Value	No.	Value	No.	Value
New Construction	3	$182,000	1	$ 75,000	4	$1,513,000
Additions	-	-	5	59,400	2	900
Alterations/Repairs	4	4,450	5	4,800	2	2,800
Total	7	$186,450	11	$139,200	8	$1,516,700
City of North Vancouver Total - 209			($14,034,796)			
1976						
New Construction	3	$200,000	2	$59,000	16	$6,660,938
Additions	1	120,000	1	5,000	-	-
Alterations/Repairs	15	72,000	5	16,700	2	1,500
Total	19	$392,000	8	$80,700	18	$6,662,438
City of North Vancouver Total - 344			($20,296,594)			
1981						
New Construction	16	$14,231,417	-	$ -	1	$300,000
Additions	-	-	1	20,000	-	-
Alterations/Repairs	14	314,300	4	17,000	5	38,600
Total	30	$14,545,717	5	$37,000	6	$338,000
City of North Vancouver Total - 287			($37,027,733)			

Table 2 Building Permits Issued in the Study Area

Appendix F Burrard Inlet Ferry System Operation Regulations

Amended Version, March 16, 1977

The Burrard Inlet Ferry System operates passenger ferries across Burrard Inlet from the Main Terminal at the South Foot of Lonsdale Avenue in North Vancouver to another Terminal just east of Pier B.C., Vancouver between the hours of 0600 through midnight to 0200 daily. Service varies from a rush hour frequency of every ten minutes to every thirty minutes in the evenings and on holidays.

Pursuant to National Harbours Board By-law A-1, Operating Regulations, Section 59, the following Regulations for the operation of the Burrard Inlet Ferry System are implemented as of 0001 hours 18th March, 1977.

These Regulations will remain in force until 2400 hours December 31st, 1977 at which time they will be reviewed.

The following Regulations apply to ferry traffic of the above system in Vancouver Harbour:

(a) Ferries shall show all around, blue strobe light at all times when underway.

(b) Ferries shall give way to all hampered vessels, including deep sea vessels and tugs with tows, and such hampered vessels shall show the lights and shapes prescribed by the International Regulations for Prevention of Collision at Sea.

(c) Ferries shall comply with the normal steering and sailing rules of the International Regulations for Prevention of Collision at Sea in respect of all traffic in the Harbour other than hampered vessels.

(d) Ferries, shall, at all times when under way, keep watch on the Harbour Radio Frequency.

Directions from the Harbour Master's Office shall supersede any other instructions with regard to Ferry movements within the Harbour.

This amended version of the Burrard Inlet Ferry System Operating Regulations cancels and supersedes that dated February 17, 1977.

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Schedule 'E' - Physical Performance Standards
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